POWER PLANT ENGINEERING

GENERATION, TRANSMISSION AND UTILIZATION OF STEAM, ELECTRIC, DIESEL AND HYDRAULIC POWER

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STEAM IN 15 SECONDS!

In recent years designers have taken well justified pride in designing steam generating plants which can be started up and brought to full steaming capacity in remarkably short periods of time; indeed intervals of only ten minutes from "cold" to full "steaming" are not numerous. Naturally, this marked a considerable advance in technique over that which obtained in former practice with fire tube and older type water tube boilers where the time involved was measured in hours.

Ten minutes, however, is hopelessly long compared to the time required for the tiny boilers in this photograph to attain full steaming capacity, for these curious vacuum-tube-like gadgets start to blow steam at 350 deg. F. just 15 seconds after operation starts. This, even the most ambitious of the quick-starting school of operators, will be forced to admit is the most super-colossal in short steaming times on record and it should turn the most generous among them green with envy.

Measuring only 9¼ in. in height, these little glass electric boilers are made in 1000, 1500 and 2000 watt sizes with evaporating capacities up to 5.7 lb. of water per hour. This is small compared with the 1,200,000 lb. per hr. rates of some of our large boilers, but these little units also have their place in the sun. Developed by Westinghouse they should have lots of uses in plants and laboratories for sterilizing, distilling and supplying steam for small processes.

Come to think of it, this is the kind of boiler plant we would enjoy operating—it would provide us much time for other things.

WITH THE EDITORS

Maintenance—The Control of Destructive Processes

POWER PLANT operation is an occupation that masters controls. It is not enough that the wheels go round, they must be kept within definite speed limits; combustion must take place at a rate that will maintain the desired heat balance; flow of steam, water, air and gases must be according to the needs of the plant; fluid pressures, temperature and voltages are maintained to meet exacting conditions.

All these are operating problems; they have to do with conditions that change rapidly under the manipulation of control equipment. Changes of another type also take place in power plants. These changes affect physical conditions of plant equipment and structures both as to dimension and strength, and are due principally to some type of corrosion, erosion or crystallization. The work of combatting these changes is usually termed maintenance—the job of caring for equipment in such a way that its condition is not changed with time and service.

Through the ages during which metals have been employed by men, engineers have learned that corrosion, the gradual eating away by chemical action, can be prevented. The available methods are not always economically applicable but every day brings new methods that are lengthening the service of metallic parts. The problem usually resolves itself into keeping substances that have a chemical affinity for each other from coming into direct contact. Painting, enameling, galvanizing, electroplating and the use of special alloys have all been resorted to with varying degrees of success. The point is to determine the cause and remove it if possible or apply some preventive method.

Erosion, the gradual wearing away of material by friction or rubbing, is an extremely helpful agent in industry but is the process that destroys or puts out of commission most of our industrial machinery. Bearing surfaces are vulnerable points of attack but improvements in design, choice of materials and lubrication methods are fortifying machinery against deterioration at these points. Likewise erosion of piston rods and valve stems has been reduced by better design of packing glands and choice of packing. Piston rings, valve seats and discs, turbine blades, fan blades and many other metallic parts subject to wear have been improved by choice of a resisting alloy. Wherever possible the maintenance man's answer to erosion problems is to have equipment so designed that parts subject to wear can be easily replaced or adjusted to take up wear.

Crystallization of metals which usually takes place prior to the cracking or breaking of a machine part under strain presents to the operator no warning of its taking place until cracking actually appears. Engineers have learned, however, that if parts are designed with a sufficient factor of safety, little difficulty will be experienced with crystallization. Other types of failures due to crystallization or embrittlement take place as a result of fabrication or welding which has subjected portions of plates or machine parts to strains that cause cracks, annealing subsequent to fabrication is the usual preventive precaution for this type of crystallization. Suffice it to say that the operator runs greatest risk of crystallization when he subjects his equipment to overloads, undue strains and vibrations.

Each of these three processes has definite services to perform for industry but in the power plant the big problem is to keep them under control.

Who Benefits?

FOR SOME reason there persists among many people an idea that if prices of a commodity can be pegged at a definite figure many of the economic ills would be settled. In spite of many efforts and failures of Government agencies to set prices for manufactured and agricultural products, an attempt is now being made, through conferences now being held in Washington, to set a minimum price for bituminous coal at the mines.

Nobody doubts that the bituminous coal mining industry is in distress and has been for years. Miners have made it a practice to strike for some cause or another nearly every year since the turn of the century. Every step of the way, miners' unions and operators have been in controversy. This condition has made it possible for independent operators employing non-union labor at lower wages to work their mines at a profit and thus upset the market.

Transportation costs come very definitely into the picture to give a decided advantage to certain favorably located mines.

The consumer demands quality along with price and in the past operators have depended to a large extent upon the quality of their product to meet competition, many even going to the extent of improving quality by washing, sizing, and dedusting their coal.

If the mining industry is to flourish, and that seems to be the main object of the price fixing program, its product must meet the competition offered by other fuels such as oil and gas which are cutting into the market extensively.

After all is said and done, who will be the beneficiaries of this experiment in price fixing? The distressed miners, like many other industrial workers, have demanded and secured Government assistance; the operators pass what they can of their difficulties on to the consumers; through the Consumers' Counsel, a Government agency, the coal users are resisting increased prices; the public is turning to other fuels in its search for more economical and convenient heat. So we ask who will benefit by this experiment in price fixing? Certainly not those miners who are let out because of competition from various sources, nor operators who for similar reasons find their market reduced, nor the consumers who must pay the higher prices established by Government edict. The answer seems to be, as always, only those who by force of circumstances are advantageously situated in mines that are and, more than likely, have always been profitable.

400 Lb.

Fig. 1. The two new 400 lb. boilers are fired by underfeed stokers and under complete automatic control

Fig. 2. (Below) A view between the boilers showing the boiler feed pumps at the rear

THE CONVERSION of an old, more or less obsolete power plant into a modern one is always an interesting process. Aside from the actual installation of new equipment involved it is usually necessary to keep the plant in operation during the transition period and this often requires considerable skill and ingenuity.

The rehabilitation of the power plant at the National Folding Box Co. in New Haven, Conn., provides an interesting example of this kind of job. This plant until last fall operated entirely on 150 lb. steam pressure supplied by a battery of old boilers. Realizing the superior economy of modern high pressure boilers and the effectiveness of full automatic control, it was decided early in 1938 to replace the 150 lb. units with two 400 lb. boilers with automatic control and also to install a new 3000 kw. turbo-generator to meet the requirements of the rising electric load. Accordingly, Frederick L. Smith consulting engineer of New York, was retained to design and supervise construction of the new plant. The work progressed through the latter part of last year and the first new boiler was placed in operation early this year; the second boiler followed soon afterward and now the plant is in full operation at 400 lb. operating pressure. The new turbine is a Westinghouse, condensing extraction type connected by gears to two 1500 kw. direct current generators mounted on the same shaft.

Minor constructional changes were required in the turbine room, but the existing boiler room building was too low to accommodate the new boilers so a new top was built on the old structure. This new top is supported at one end by the old building columns and at the other end on new columns. These new columns and also the columns for the new boilers are supported on 12 in. steel pipe piles filled with concrete reinforced and driven down to bed rock by jacking. The old boilers were filled with water and used as weights to drive down the pipe columns or piles. The mud and sand was washed out as the several sections of piles were jacked into place.

The old boiler house had an overhead coal conveyor installed in a pent house. One half of this conveyor was first cut off so that the remaining half could continue to serve the old boilers while the two new boilers were being installed. Then, when the new boilers were in place, a new coal conveyor was installed and placed in operation. This work was done over one week end; the old conveyor was shut down on Saturday and the new one placed in operation on the following Tuesday morning.

Before the rehabilitation program was started the plant contained 6 B. & W. boilers operating at 150 lb. pressure and all equipped with Murphy stokers. Four of these were removed to make way for the two new 400 lb. units.

This was accomplished in two operations; first, two old boilers were removed and the four remaining old boilers carried the summer load. When the first new boiler was placed on the line the entire load of

Plant At National Folding Box Co.

90,000 lb. was carried by this new boiler. The second pair of old boilers was then removed and the second new boiler installed. Since the new boilers were placed in service, however, the remaining two old boilers have been removed so that now the plant contains only the two new 400 lb. pressure units.

In addition to the installation of the new boilers, the project also involved the construction of two new steel stacks. These are mounted directly on the building steel and rise 72 ft. above the induced draft fan floor.

The two new boilers are bent tube units designed and manufactured by The Bigelow Co. They are designed for a working pressure of 450 lb. and 618 deg. total temperature and are rated at 89,000 lb. per hr. maximum output. Each unit has 7536 sq. ft. of surface in the boiler, 1018 sq. ft. in the water walls and 3234 sq. ft. in the economizer. The economizer is of the steel tube extended surface type made by The Foster Wheeler Corp., having 14 rows of elements, 7 rows wide. These are also designed for 450 lb. working pressure. The gases leave the economizer at 405 deg. and the temperature of the feedwater to the economizer is 260 deg. F.

Both boilers are fired by Westinghouse Electric & Mfg. Co. 6 retort underfeed stokers with link grates and hydraulic variable speed motor drive. The stokers, as is nearly all equipment, are driven by direct current motors.

The elevation shown in Fig. 5 shows the arrangement of the entire steam generating equipment. This is simple and direct; the forced draft fans are in the basement, the induced draft fans on the top floor above the boilers. The economizer is at the rear between the second and third floor levels.

Ash is removed from the ashpit at the rear of the unit in the basement and carried away by an existing recessed steam jet conveyor.

The boiler feed pumps are placed back of the boilers on the operating floor and the deaerating feedwater heater on the induced draft fan floor between the two stacks.

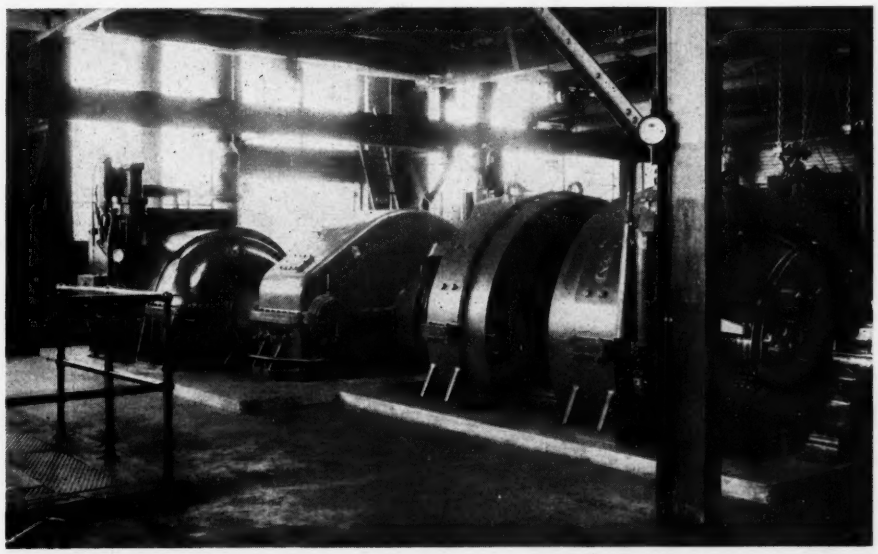


Fig. 3. (Left) The new 3000 kw. turbogenerator with its reduction gears and two 1500 kw. direct current generators on the same shaft

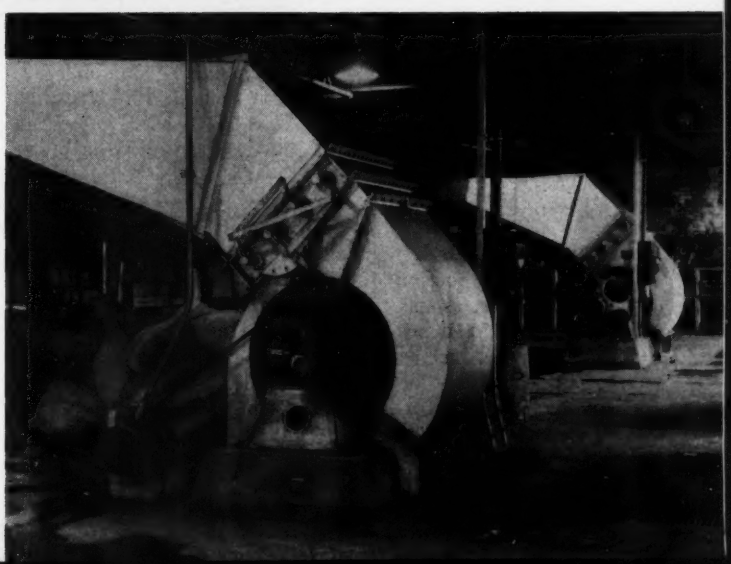


Fig. 4. (Below) A view in the basement showing the forced draft fans

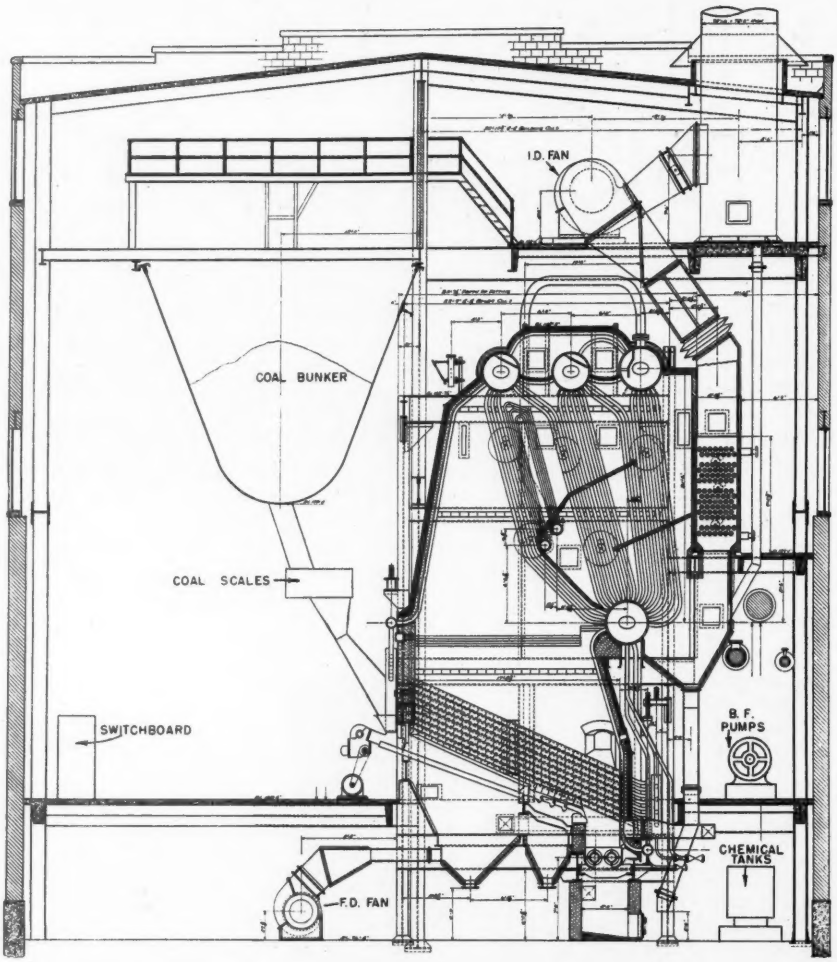


Fig. 5. Cross section through boiler house showing arrangement of boiler and associated equipment. The draft system is simple and direct; with the forced draft fans in the basement the passage of the air and gases is upward through the boiler to the stack

Two booster pumps are installed in the basement which pump water from the return tank to the deaerating heater. These are 300 g.p.m. units, one turbine driven and the other motor driven. The boiler feed pumps, also 300 g.p.m. units, one a 2½ in., 4 stage machine operating at 3500 r.p.m. and driven by a Terry turbine and the other a 3 in., 6 stage unit with a rated speed of 1750 r.p.m. driven by a variable speed d.c. motor. Both the boiler feed and booster pumps are Pennsylvania Pump & Compressor Co. units.

Water treatment consists in the addition of caustic and Buromin to the feedwater. These chemicals are fed continuously by means of two small Hills-McCanna motor driven pumps. This equipment is shown in Fig. 8. The Buromin is fed directly into the lower drum of the boiler while the caustic is fed into the main feed line to the economizer.

Both booster pumps and boiler feed pumps are provided with orifice valves and piping connections which permit a portion of the water passing through the pumps to return to the feedwater heater. This precludes the possibility of the pumps becoming overheated as a consequence of the churning of the water in the casing at times of low load when little or no water is fed to the boilers. The orifice valves permit only a certain amount of water to circulate.

Coal is delivered by railroad cars and carried up to the overhead conveyor in the boiler house by an inclined bucket conveyor on the outside of the building. The overhead conveyor then delivers the coal into the overhead bunkers.

From the bunkers the coal is drawn through spouts in the conventional manner and after being weighed by automatic electric scales is delivered to the stoker hoppers. The stoker hoppers are fitted with "Conical" coal spreaders.

An interesting feature of the coal handling system is the vibrators attached to both the coal bunkers and the spouts leading to the coal scales. Quite often wet coal has to be burned and this had a tendency to hang up. So Mr. Hyde, the chief engineer, installed these vibrators. They consist of vibrating air hammers, one attached directly to the underside of the steel coal bunker between the two spouts leading to the coal scales, and the other mounted on a steel support attached to the spouts just above the point where they converge.

These vibrators, which are made by the Peerless Vibrator Co. of Milford, Conn., are controlled automatically by an electrically operated valve in the air line supplying the vibrators with compressed air. The air pressure used is around 80 lb. per sq. in.

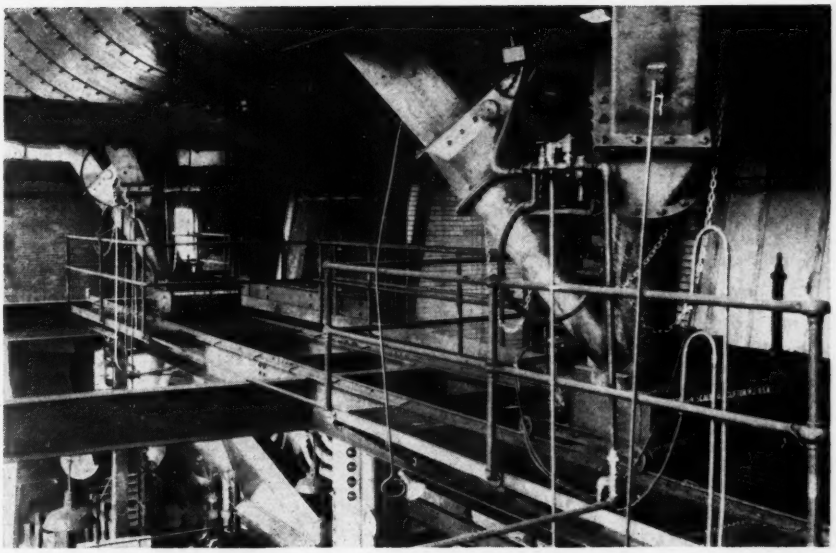


Fig. 6. A view of the automatic electric coal scale. This view shows the pneumatic vibrators installed to dislodge coal that may tend to pack due to high moisture content

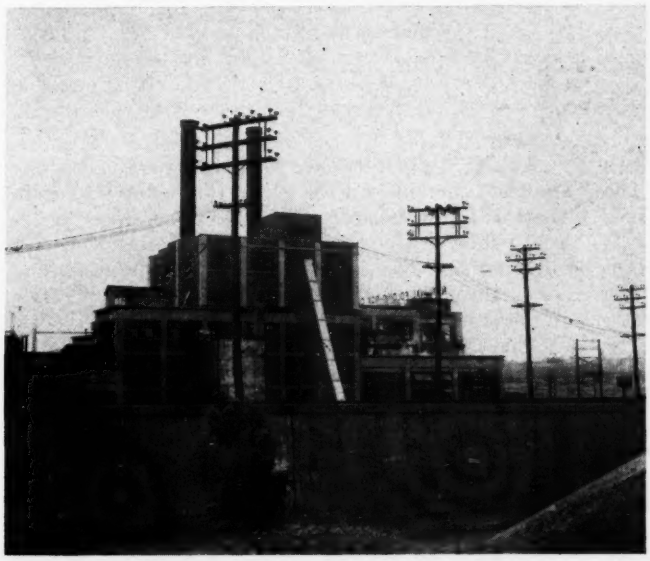
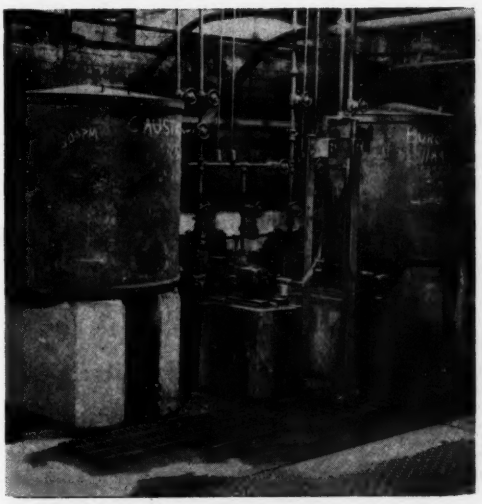


Fig. 7. At the left is shown an exterior view of the power plant. Note the two new steel stacks and the inclined coal conveyors on the outside of the building

Fig. 8. Lower left. The chemical tank and electrically driven pumps used in the treatment of feedwater

Fig. 9. Lower right. The new combustion control board. This board, as will be noted, is symmetrically arranged with a panel common to both boilers in the center, an individual panel for each of the two boilers on either side of the center panel and 4 feeder panels at each end for controlling the auxiliary motors associated with the boiler equipment. Normally the boilers are under full automatic control but by means of switches on this control board they can be changed to "manual" control



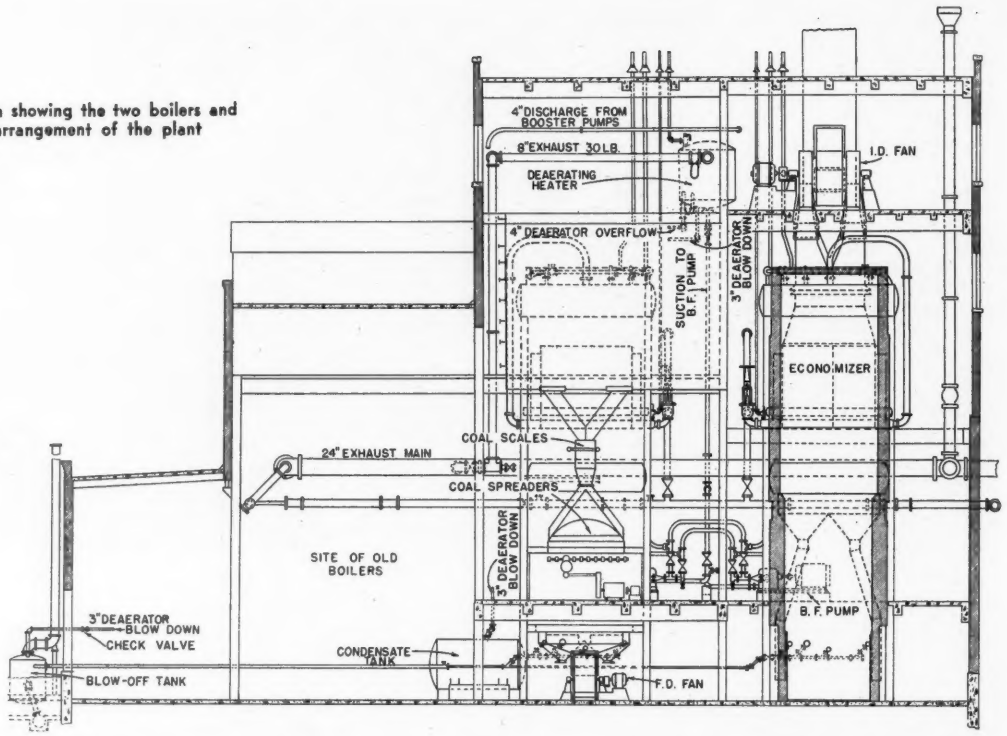


Fig. 10. Elevation showing the two boilers and the general arrangement of the plant

In case wet coal tends to hang up, the feeder belt to the automatic coal scales would continue to run indefinitely since it is controlled by the amount of coal in the scale. Therefore, after the pulleys carrying this belt have turned through a certain predetermined number of revolutions—say for a minute—without filling the scale hopper, a time delay relay closes which, in turn, opens the valve to the vibrator. The operation of the vibrator dislodges the coal, permitting it to feed to the scale and when the hopper is filled the vibrator is automatically shut off.

This device has proved extremely effective since its installation in handling wet coal. The vibrators are mounted as shown in the sketch, Fig. 13. At the same time the vibrators are cut in an electric horn sounds to warn the operators that the coal has hung up.

The relay which controls the operation of this device is a Westinghouse relay with a time delay that can be varied from 4 to 80 seconds.

Control of the boilers and the associated equipment is entirely automatic, using the "Metermax" system of Leeds & Northrup Co., and regulating the draft through adjustment of the dampers. The entire control is centered on the main boiler control board located in front of the boilers. This board consists of a center section containing the instruments and controls common to both boilers, two side panels containing the instruments for each of the two boilers and, flanking these on each end are two sets of feeder panels for controlling the auxiliary motors associated with the boiler equipment.

Normally the boiler is under full automatic control but by means of the switches on the control panels, it can be converted to "manual" control instantly when necessary.

As already pointed out, the plant operates entirely on direct current—all the generators being d.c. units. There is a low capacity tie with the a.c. lines of the local public service company but this is provided only for emergency conditions to supply a small number of lamps throughout the plant, and to start operation of the stokers.

The stokers are driven by direct current motors but in addition there is mounted at the side of each direct current motor a small a.c. motor (one horsepower units). These a.c. motors have V belt pulleys which can be belted to similar pulleys on the stoker drive shaft when necessary. Under emergency conditions these a.c. motors can, therefore, operate the stokers at low load.

So much for the boiler room; now we will discuss, briefly, the work done in the turbine room. The turbine room, as mentioned at the beginning of this article involved no major structural changes except such foundation work as was incident to the setting of the new turbine.

At the present time the turbine room contains four turbogenerators, three old units and the new one. Two of the old units, one a 1000 kw. machine and the other a 500 kw. unit, still operate on 150 lb. steam pressure through reducing valves from the 400 lb. system.

The steam end of the remaining old unit was rebuilt to operate on 400 lb. pressure but the capacity remains unchanged. It is a 1000 kw. machine.

The new turbine, like the three older machines, is a Westinghouse unit and consists of a condensing extraction type turbine built for operation at 400 lb. pressure, 618 deg. F. t.t. and having a speed of 3600 r.p.m. This turbine is geared to a shaft operating at 514 r.p.m. and carrying two 1500 kw. direct current

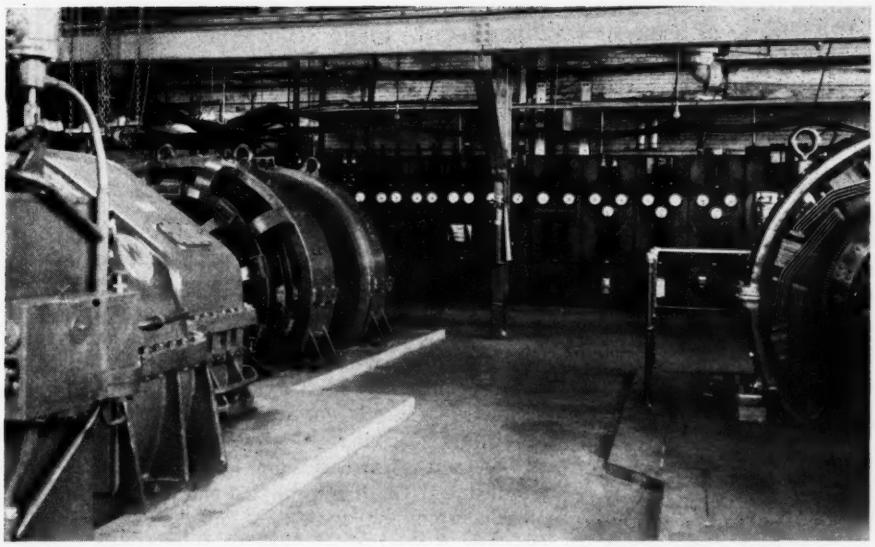
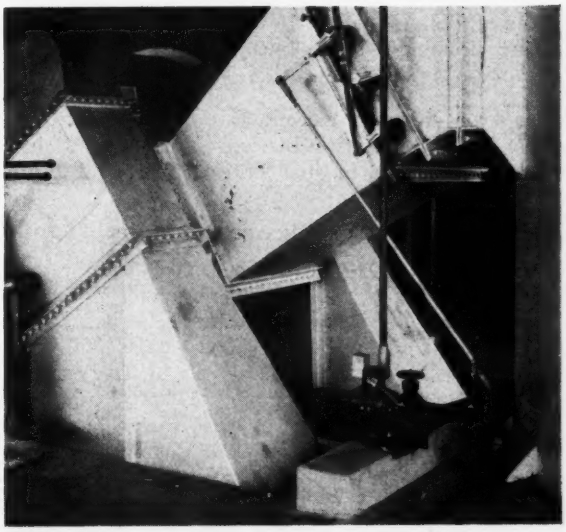


Fig. 11. A view in the turbine room with the new turbogenerator at the left

Fig. 12. Damper operating mechanism on the forced draft fan dampers. These are under automatic control

generators. All of the generators are geared units, but only the new machine and one of the 1000-kw. units are condensing units, the others all back pressure machines. The new unit is designed for the extraction of 70,000 lb. of steam per hr. at 30 lb. pressure. This steam is used in process in the mill and can be augmented by steam taken directly from the 400 lb. line through reducing valves and a desuperheater. The pressure in the extraction line is maintained constant within close limits by an automatic extraction valve. With an increase in extracted steam demand, the extraction valve moves in a closing direction to pass more steam to the extraction line and less to the turbine exhaust. Conversely, with a decrease in extracted steam demand the extraction valve is moved in an opening direction to pass less steam to the extraction line and more to the turbine exhaust. At the same time the governor valves are closed to supply less steam.

A view of the new turbine is shown in Fig. 3. The reduction gear between the turbine and generator shaft is of the single plane, double helical, single reduction type comprising a pinion and gear having their centerlines in the same horizontal plane and supported in a common housing. It provides a reduction of speed from 3608 to 514 r.p.m.



The installation of 3000 kw. of additional direct current generating capacity made necessary extensive alterations in the bus arrangement back of the main switchboard. Considerable copper was added and new panels were installed for the control of the new machines.

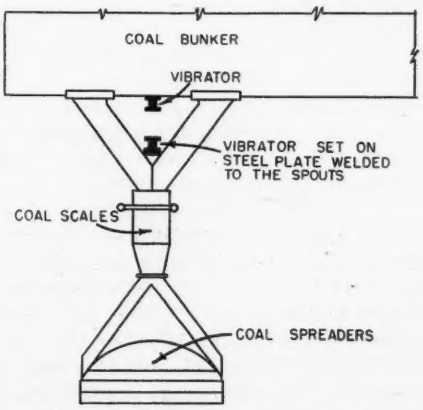


Fig. 13. Sketch showing location of the vibrators on the coal bunker

Principal Equipment at the National Folding Box Co.

Boiler Equipment

Boilers—2 Bent tube designed for 450 lb. w.p. 618 deg. t.t., 89,000 lb. per hr. max. each with 7536 sq. ft. in boiler, 1018 sq. ft. water walls and 3234 sq. ft. in economizer—The Bigelow Co.

Economizer—2 Steel tube extended surface type 3234 sq. ft. arranged in 14 rows of elements high 7 rows

wide. Designed for 450 lb. w.p. Gas leaving economizer 405 deg. F. Feedwater to economizer 260 deg. F.—The Foster Wheeler Corp.

Stoker—2 Underfeed, 6 retort, link grate, hydraulic drive variable speed motor drive—Westinghouse Electric & Mfg. Co.

Stoker Oil Pumps—Schutte & Koerting Co.

Coal Spreaders—Conical coal spreaders on stoker hoppers.—Stock Engineering Co.

Vibrators—Peerless Vibrator Co.

Forced Draft Fan—2—35,000 c.f.m. at 100 deg. F., 5.5 s.p. driven by Westinghouse variable speed d.c. motors, damper controlled—American Blower Co.

Induced Draft Fan—2—55,000 c.f.m. at 478 deg. F., 5.5 s.p. driven by Westinghouse variable speed d.c. motors damper controlled—American Blower Co.

Smoke Stacks—2 Steel stacks 6 ft. by 6 ft. dia. by 72 ft. high—The Bigelow Co.

BOILER ACCESSORIES

Feedwater Regulator—Copes—Northern Equipment Co.

Soot Blowers—Vulcan Soot Blower Co.

Blow-off Valves—Yarnall Waring Co.

Gauge Columns—Reliance Gauge Column Co.

COAL AND ASH HANDLING

Conveyor—Robinson Branin Co.

Coal Scales—Automatic Electric—Richardson Scale Co.

Ash Conveyor—8 in. dia. "Steamatic"—United Conveyor Corp.

FEEDWATER HEATER AND PUMPS

Feedwater Heater—Deaerating type, max. capacity 150,000 lb. per hr.—Cochrane Corp.

Atmospheric Relief Valve—Cochrane Corp.

Boiler Feed Pumps—1—2½ in. 4-stage, 300 g.p.m., 1150 ft. head, 3500 r.p.m. driven by Terry turbine. 1—3 in. 6-stage 300 g.p.m., 1150 ft. head, 1750 r.p.m. driven by Westinghouse variable speed d.c. motor—Pennsylvania Pump & Compressor Co.

Booster Pump—2—3 in. single stage 300 g.p.m., 155 ft. head, 1750 r.p.m.—one driven by Terry turbine —one driven by constant speed d.c. motor—Pennsylvania Pump & Compressor Co.

CONTROL AND INSTRUMENTS

Combustion Control System—"Metermax" combustion control regulating draft through damper adjustment. Leeds & Northrup Co.

Pressure Gages—Republic recording—Republic Flow Meters Co.

Level Indicator for F. W. Heater—Republic Flow Meters Co.

CO_2 Recorder—Republic Flow Meters Co.

Steam Flow Recorders—Republic Flow Meters Co.

Temperature Recorders—Leeds & Northrup Co.

Desuperheat Control—The Swartwout Co.

GENERAL EQUIPMENT

Turbogenerator—1—Condensing extraction type turbine designed for 400 lb., 618 deg. F. steam extracting a max. of 70,000 lb. at 30 lb. gage pressure; connected by gears to 2—1500 kw. 250-volt d.c. generators mounted on the same shaft. Westinghouse Electric & Mfg. Co.

Condensate and Blow-off Tanks—The Bigelow Co.

Piping—C. N. Flagg & Co.

Valves—Chapman Valve Co.

Switchboard—Westinghouse Electric & Mfg. Co.

Electrical Work—The Stevens-Fitch Co.

Boiler Setting—Geo. Allen & Son, Inc.

On the whole this forms an excellent example of what can be done to improve the operation and performance of an old plant. The equipment in this plant was still in good shape when the rehabilitation work was started, but it was obsolete compared to modern practice and the economies of modern high pressure steam operation are such that the costs involved in effecting this rehabilitation are well justified. The new equipment has been operating too short a time to enable us to present accurate figures, but the preliminary results indicate a substantial saving.

The work was carried out under the direction of Frederick L. Smith, consulting engineer of New York. In concluding, we wish to acknowledge our indebtedness to the Frederick L. Smith organization for assistance rendered in furnishing data and drawings and also to Mr. Peck, plant engineer, and Mr. Hyde, chief engineer, of the power plant at the National Folding Box Co. for many courtesies extended to us on our visits to the plant.

Excavation Uncovers Old Conduit System

WORKMEN DIGGING on the Cornell University campus have unearthed two sections of rusty cast-iron pipe which, on inspection, have been identified as part of the conduit laid in 1875 for the first outdoor electric lighting system in the Western Hemisphere. It extended from Morrill Hall to Sage Chapel. Though buried for 64 years, the pipe could still perform its original function, according to professors of the School of Electrical Engineering. The copper wire in the center is protected by muslin strips and the surrounding space filled with beef tallow, originally purchased from an Ithaca butcher for the experiment.

In 1875 Professors William A. Anthony and George S. Moler built in the Cornell shops the first dynamo in America and used it to provide electricity for lights on the campus, when New York and Paris were still illuminated by flickering gas jets. The dynamo, still in running order, as was dramatically demonstrated at the 60th anniversary of the College of Engineering in 1931, is on display in Rockefeller Hall. Professors Moler and Anthony, by their early work in the field of electricity, made Cornell a pioneer in electrical engineering and laid the foundation for the first department and later the first School of Electrical Engineering in this country.

NOTABLE recent uses of nickel cast iron have been in the crankcse of air-conditioning compressors of Westinghouse Electric and Mfg. Co., where requirements are light weight and good machinability in a rather complex casting; and in the impeller of a pump for coolants and lubricants of Pioneer Engineering and Mfg. Co., where resistance to erosion and corrosion was of prime importance.

Recent technical literature has made considerable reference to control of dissolved oxygen and pH of boiler water, the limits of such treatments need more thorough discussion, which is the author's objective in presenting the following article.

pH and Oxygen Control By Recirculation

By BILL MADDOCK

Power House Technician
Tucson Gas, Electric Light & Power Co.

IF ONE refers to a standard hand book he is likely to find the recommendations for boiler water something as follows:

0-250	lb. per sq. in.	pH 10.5 ASME ratio 2
300-800	lb. per sq. in.	pH 11.0 ASME ratio 3
800-over	lb. per sq. in.	pH 11.0+ ASME ratio 3

and for feedwater, a pH of not less than 7.0.

Figure 1 shows the proportions of boiler feed and boiler water necessary to give a desired pH of the feedwater based on original pH values as noted. The minimum attack on iron is with feedwater having a pH of 9.0 to 11.0. Brasses and bronze have a tendency to dezincify in contact with water having a pH of over 7.5. The attack by the dissolved gases increases in acid solutions and pH values of 7.5 to 8.0 help to reduce this factor. Ordinarily the condensate from the condenser or evaporator is slightly below 7.0, or is on the acid side.

In existing low pressure plants very little trouble has been experienced with the feed piping and if any treatment is used at all it is usually done in and for the boiler. The periodic cleaning of tubes and drums has long been regarded as a necessary evil and modern treatments have been classed as not applicable to the old equipment. With the advent of high pressure units, coupled with feedwater heaters and economizers, and high heat rate boilers, the water conditions are being more carefully watched. It has been found not only advisable to improve the boiler water treatment, but the feedwater as well.

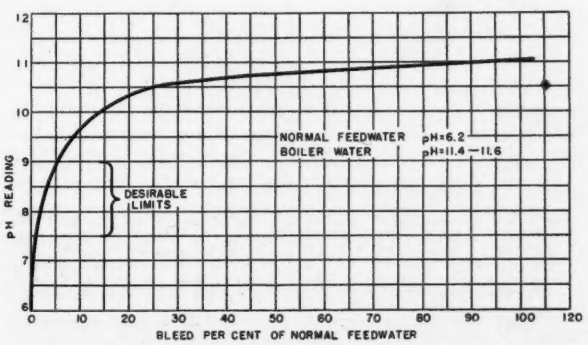


Fig. 1. pH of boiler feedwater with various percentages of bleed

To increase the pH of the boiler feedwater, continuous alkaline feeders have been placed in the lines. Thus with a steady flow of solids to the boiler it has become necessary to employ continuous "blowdown." The method as far as the water is concerned is excellent, but even with the best of heat reclaiming equipment about 25 per cent of the heat of the liquid is lost either in the reclaimer or in the furnace itself. Add to this the additional cost of pumping and evaporating new make-up and it can readily be seen why plant executives have "shied" away from installing complete water treatment facilities.

Entrained Gases

Even after the pH of the boiler and boiler feed has been corrected to the desired value, there is the problem of eliminating the entrained gases. The carbon dioxide will be neutralized in the process of increasing the feedwater pH value, leaving the dissolved oxygen yet to be removed. If all of the feed piping is to be protected, the oxygen removal should begin in the condenser. Should the flow arrangement include an open hotwell or surge tank, however, it is of no use to try for complete de-aeration ahead of them. The open hotwells and heaters can be converted to closed types with good results. If the open surge tank is replaced, it is possible to use the condenser as a surge tank.

All of the mechanical methods of removing gases from the water depend on a decreasing solubility with a decrease in the surface tension of the liquid. In other words, as a liquid boils, the gases are driven off. Theoretically it is impossible to dissolve a gas in boiling water, and it should make little or no difference if the boiling is done at, above, or below atmospheric pressure. A few arguments for higher and lower pressures are given as follows:

Advantages of sub-atmospheric pressures[1]

1. Enables the use of bleed steam from the lower sections of the turbine, giving a greater net heat return per pound of steam generated.
2. It is possible to use at least one stage of the air

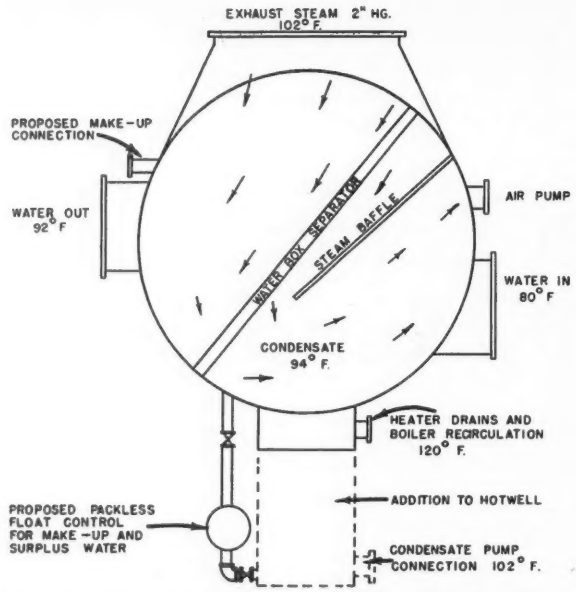


Fig. 2. Diagram indicating flow of entrained air through condenser

pumps already in service on the condenser.

3. Gives protection to more of the feed piping.
4. It is possible to use the condenser itself as the de-aerating device.

Advantages of pressures atmospheric and above

1. Eliminates extra piping under partial vacuum, and decreases the chances of air leakage.
2. Does not require highly efficient air pumps.
3. Control is likely to be more stable.

The condenser with its air pumps and large cooling system already in service should be a good place to do any and all of the mechanical de-aeration. In fact, it appears that if the theory were correct, the condenser would automatically take care of the de-aeration. The point is, that the correct conditions do not and can not exist in the usual condenser design. In Fig. 2 it will be noted that the air pumps are so located as to force steam circulation over the entire tube area. Also it must be noted that the air is the last to be removed and its path is directed over the water collecting on the lower tubes.

Hotwell Temperature

According to "Gebhardt" the hotwell temperature may be as much as 15 deg. cooler than the boiling point corresponding to the condenser pressure. "Kent," more conservatively, places the figure at 7.5 deg. In any case there is an undercooling of the condensate that may represent losses of 1 per cent of the heat supplied to the boiler[2]. Not only does the undercooling become a sensible heat loss but it enables the condensate to re-dissolve the gases. As with the regular de-aerating heater, if the liquid can be made to boil, no extra mechanical means are necessary. If the boiler water recirculation along with the heater drains, etc., can be fed to the hotwell at or near 125 deg. there should be sufficient flashing to drive off the dissolved gases. As pointed out before, the make-up can be fed directly to the condenser for de-aeration along with the condensate.[3] The arrangement for using the condenser as a surge tank is shown in Fig. 2.

The last traces of oxygen may be picked up with agents such as sodium sulphite or some ferrous compounds. If the A.S.M.E. ratio is to be followed, the use of sulphite precludes the addition of sodium sulphate. Eventually all of the sulphite will become sulphate and unless there is need for excessive blow-down the ratio will be more than maintained by the conversion of the sulphite. Any continuous feed of sulphite to the boiler feed would call for a continuous blow-down on the boiler.

Here again comes the balancing of a continuous blow-down against the benefits of a treated feedwater. The recirculation of 1 or 2 per cent of the boiler water has much to offer in the way of solving both problems. If a sufficiently high concentration of sulphite is held in the boiler (50 to 120 p.p.m.), there will be ample sulphite in the boiler feed to pick up the last of the oxygen. Also the some amount of recirculation will, in all probability, raise the pH of the feedwater to the desired value. Thus there will be a saving in the heat lost on the blow-down, in chemicals, water, and a material saving in the cost of proportional feeders. There is some evidence to show that not over 50 p.p.m. of sulphite should be maintained in boilers of over 600 lb. per sq. in.

The extra amount of heat directed to the condenser should be taken up by the increase of the condensate temperature, and no extra load should result on the condenser cooling system. In additions to the savings listed in the preceding paragraph, there will also be a saving in the steam and water used in connection with the operation of a separate de-aerating heater[4].

By the proper direction of bleed heater drains it should be possible to eliminate the separate de-aerating equipment. Also by the use of a small amount of recirculated boiler water it is possible to remove the last traces of oxygen, raise the pH of the feedwater, eliminate the cost of proportional feeders, and eliminate the continuous blow-down equipment if the make-up is derived from evaporators and condensed returns.

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[1]Some authorities on condenser design claim that the most effective de-aeration is done at atmospheric pressure. There are decided advantages of such types as pointed out, but if the equivalent or better conditions can be maintained within the condenser (barring further contamination) no other mechanical de-aeration should be required.

[2]The author agrees that "Gebhardt" is out-moded, but so are some of the condensers that could be used for de-aerating purposes. "Gebhardt" was in line with their design and the figures are still applicable to their operation. It was called to the attention of the writer that some of the new condenser designs have actually had negative depression, meaning that the hot-well temperature was above that of the exhaust steam. One of the first laws of thermodynamics is to the effect that one body may not transfer heat to another body of higher temperature. Where would the heat come from that would raise the temperature of the condensate water higher than that of the steam from which it was condensed, unless the outlet cooling water was higher than the exhaust steam temperature?

It is the theme of this article to raise the hot-well temperature, in order to drive out the gases, by adding heat from an outside source. If it can be done with or without the addition of heat, it only helps to prove that the real place for mechanical de-aeration is in the condenser.

[3]Here the statement in regard to "no further mechanical means are necessary" was said to be contrary to the best high pressure design. The writer has no quarrel to pick with designers. The heat balances and flow sheets of new units are carefully planned, and the de-aeration equipment is fitted to the plans. The writer does not suggest, however, that all oxygen control stop just because the limit of the mechanical means has been reached.

[4]The defenders of separate systems claim that the heat to such is reclaimed. The author agrees that most of the heat supplied is reclaimed, but what of the 20 per cent loss in the boiler to make the steam and the extra pumping and firing rate needed to produce it?

Part II. Effective boiler operation depends not so much on the individual characteristics of the equipment selected as on how well the auxiliaries operate together as a coordinated unit. Whether manual or automatic control is contemplated, the problem of control and coordination should receive as much study as the heat balance.

COMBUSTION CONTROL SPECIFICATIONS

By

RICHARD H. MORRIS
Engineering Editor

REGARDLESS of its extent, the general purpose of automatic combustion control is to coordinate the boiler auxiliaries and the characteristics of these auxiliaries place very definite limitations on what automatic control can accomplish. While the plant is being designed it is, therefore, important to keep in mind the general features of the anticipated control arrangements; select auxiliaries and auxiliary drives with the necessary flexibility to meet the expected load conditions; and, arrange them so that automatic control may be easily and simply applied. If a boiler plant with properly synchronized auxiliaries is expected, the designer should give the control system the same study as the heat balance.

This does not mean that the boiler plant should be designed around the automatic combustion control, for, obviously, fuel and load conditions are the primary factors to be considered. Susceptibility to control is, however, a practical measure of the utility of a modern plant, whether ability to follow wide and rapid load changes, high thermal efficiency or operating convenience is paramount. Modern boiler and auxiliary equipment is susceptible to varying degrees of flexibility and this, together with a convenient arrangement, should be considered regardless of how the operating responsibility is divided between the operator and automatic equipment.

Unfortunately, it is impossible to make a definite division of responsibilities as can be done with many industrial process controls predicated on complete elimination of the operator. There are so many unpredictable variables in the boiler room that, in most cases, automatic control is designed to aid the operator rather than relieve him of all responsibility.

Manual vs. Automatic Operation

Some responsibilities must therefore be divided. Automatic control will carry on for extended periods until some unforeseen or unpredictable condition arises and the operator must then make adjustments for the new condition. Surprising as it may seem, the demand for unattended operation comes from the small plant, usually in service industries such as laundries or heating plants where a single engineer has many duties to perform and must be away from the boiler for considerable periods. The advisability of this may be questionable but the fact remains that the practice is not at all uncommon and the need is being successfully met by automatic combustion control of the simple and more inexpensive type.

Standardization

Considering the plants with a more complete operating personnel, however, the operating responsibilities mentioned above may, for convenience, be divided into two groups: those that must be made continuously, immediately and accurately such as changes connected with the combustion process; and those which are less critical of adjustment, such as coal supply to the bunkers. The first are ideally suited to automatic control, the second should be left to the operator.

The history of automatic combustion control dates back almost as far as that of the boiler. By the end of the World War it was well developed along two extremes: the very simple systems growing out of the earlier damper controllers; and the very complete systems which led one prominent engineer to say 20 yr. ago, "There are some combustion control systems in which an attempt is made to regulate . . . nearly everything but the fireman's morals."

In the intervening two decades, combustion control has developed with the power industry and there are no longer wide gaps left unfilled. Also there is now a much better understanding of the fundamental problem of control and regulation so automatic features can be, if necessary, successfully extended much farther than they could 20 yr. ago. At the same time a

more rational appreciation of what needs to be controlled automatically led to a decided standardization which, with trends in boiler practice, made automatic control not only economically justified but often absolutely necessary. Fuel economy, although an important item, is, however, but one of the numerous benefits.

To a certain extent the size and numbers of the boilers determine the need and economical extent of automatic control. The cost of a given control system varies almost directly as the number of boilers, while the fuel savings vary directly with the steam output. Obviously, therefore, the larger the boiler, the greater the amount which can be justified for automatic control for a given plant. Cost of fuel has a direct or fuels and auxiliaries selected and to a lesser extent upon the boiler itself. From the standpoint of complete boiler operation the control problem may be divided into nine parts:

1. Boiler proper, or steam making surface including water walls.
2. Economizer.
3. Air heater.
4. Superheater.
5. Feedwater supply.
6. Fuel supply to intermediate storage or bunker.
7. Fuel supply to furnace.
8. Air supply.
9. Removal of gases of combustion from the furnaces to the atmosphere.

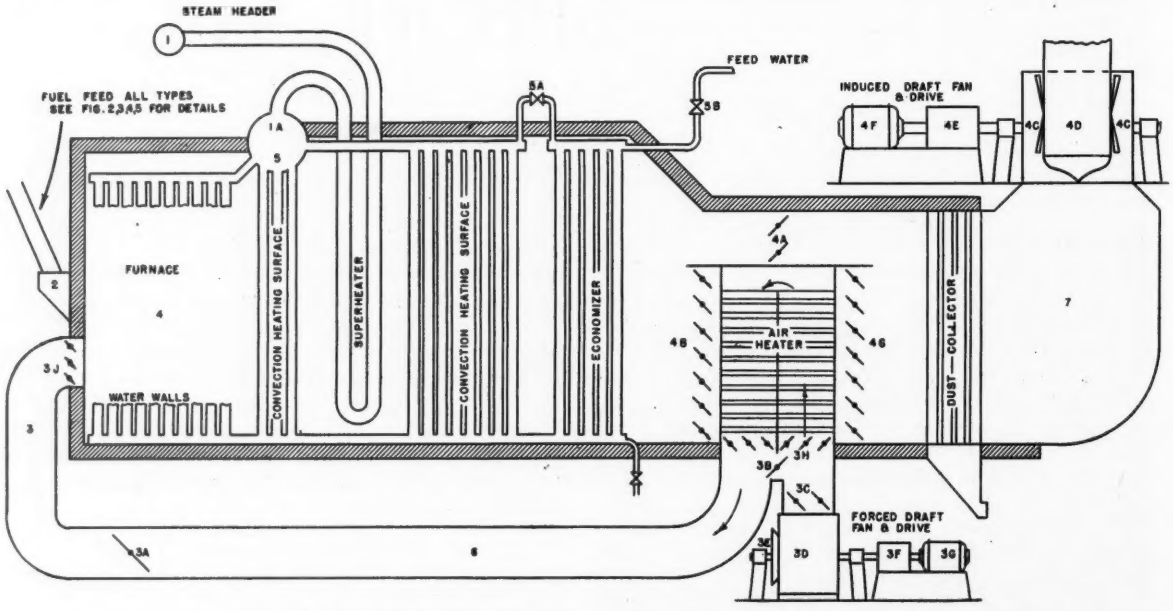


Fig. 1. Diagrammatic arrangement of a complete boiler unit showing the common points of control. The firing arrangements and control depends on the fuel used and details are shown later. This and the other drawings are diagrammatic. They show all the points and methods of control commonly used but no single boiler will use them all. Figures in the drawing are explained by the following notes

1—Steam header pressure—(Drum pressure 1A minus pressure drop through superheater and valves)—Primary control point for automatic combustion control. Pressure variations at this point used to proportion fuel, 2, and air, 3, in accordance with steam load in desired ratio to each other.

2—Fuel feed—For details of automatic control points with different fuels see Figs. 2 to 5 of Part III.

3—Air Flow—Controlled automatically from variation in the steam pressure, 1, or furnace pressure, 4. This is done through damper 3A, 3C, inlet vanes 3E, or by changing the speed of forced draft fan 3D by variable speed device 3F or variable speed drive 3G. Damper 3J is controlled manually, to give proper distribution between burners, better turbulence or regulation of zone pressures on forced draft stokers.

4—Furnace Pressure—Depends on balance between air flow to, and gas flow from, the furnace. The air flow must be varied in accordance with the steam load, and the volume of gases which result from combustion is a function of the air flow. Removal of gas from the furnace is controlled automatically from variations in the steam pressure, 1, or furnace pressure, 4. This is done through damper 4B, inlet vanes 4C or by changing the speed of induced draft fan 4D, through variable speed device 4E or variable speed drive 4F. If the air flow is controlled from steam pressure 1, the gas flow is controlled from furnace pressure 4, and vice versa. Both arrangements are used, the most desirable method in a given case depending on the equipment involved.

5—Drum level—Controlled automatically by feedwater regulator through valves 5A or 5B.

6—Preheated air temperature—Excessive air temperature, 6, at high loads, or, low gas temperatures, 7, at low loads, can be controlled by operating by pass damper 3B. Air temperature can also be reduced by opening bypass damper 4A. Either may be automatically controlled but are usually arranged for manual operation. Proper operation of dampers 4A, 4B, 4G, 3B and 3H cuts out air heater completely and a bypass similar to 4A may be used to cut out the dust collector.

bearing and the service conditions are important. This is the case with large boilers which would be difficult if not impossible to operate manually. Base load operation is most susceptible to efficient manual operation. As load variations increase, automatic control becomes more necessary and in certain cases where steady steam pressure is a prerequisite, automatic control is a necessity quite aside from any increase in combustion efficiency which may be expected.

Details of the control system depend upon the fuel

In the face of encroachment by water walls, superheater, economizer and air heater, the boiler convection heating surface is declining in importance but still acts as the base around which the unit is built. The complete steam generating unit has definite characteristics which the designer can control within rather wide limits to meet specific operating conditions but which the operator can change but little without impairing combustion efficiency. As a combustion control problem, the boiler proper is of importance

only as its inherent characteristics limit the operation of auxiliaries and set a bogey for the performance of the control equipment.

This is true also of the economizer which is important in flattening out the boiler efficiency curve but is of importance from the combustion control standpoint only when it introduces circulation and feedwater regulation difficulties into the boiler proper.

Air Heaters

Over the normal operating range the air heater is not controlled but is left free to follow its natural characteristics. Often damper control is added: to facilitate limiting the air temperature to a maximum value at high load by bypassing some of the hot gases around the unit; to prevent cooling the gases below the dewpoint at light loads by bypassing some of the air; or to allow low load or emergency operation on natural draft. These dampers may be operated by independent thermostatic controls but the limits are not critical and manual operation is usually adequate. Drying air or gas for direct fired mills taken from the furnace, from hot side of the air heater or from some intermediate point on the air heater a boiler must also be provided with some form of damper control. This is, however, more definitely connected with fuel supply to the furnace and in most cases manual concontrol is adequate.

In the past the superheater too, whether of the convection, radiant or combination type, was left free to follow its natural characteristics and affected the combustion control only indirectly as changes were made in surface or in baffling to give better gas distribution in the furnace. Such changes usually make a readjustment of the air flow regulator necessary. Recently temperatures in the 900 deg. F. range have made the problem of superheat control quite critical. This may be handled in many ways, of which at present the bypass damper arrangement is most popular. So far, manual and automatic control are about evenly divided. Automatic control when used is separate from the combustion control.

Although independent of the combustion control, it may have an effect indirectly through disturbance of the gas flow and boiler circulation unless the control points have been carefully selected. Still more recently the control of temperature by a separate burner or burners has been introduced and this of course has a direct effect on the combustion control equipment. The steam temperature problem is far from settled and eventually may come directly under the combustion control. At present it is of importance only in special cases and in the average boiler the superheater, with the boiler, economizer and air heater, may be left to take care of themselves as far as combustion control is concerned.

Feedwater

Feedwater regulation is one of the oldest and from the safety standpoint, most important automatic operations used on the boiler. Originally the boiler water level was the sole and independent point of control and always acts as the final adjustment. Variable speed boiler feed pumps can be easily and adequately controlled by an independent regulator or pump governor to maintain, at the feedwater valve inlet, a pressure nearly constant at all loads or varying with the load as desired. With constant speed pumps the same result, as far as the feedwater regulator is concerned, can be obtained by means of an excess pressure regulator which controls the pressure differential across the feed valve.

Sometimes the steam flow or both steam flow and feedwater flow are brought into the picture as secondary feedwater control elements and the whole is occasionally tied in with the combustion control system so as to vary the feedwater or excess pressure with the steam load. In all but the most exceptional cases, however, the feedwater regulator, excess pressure regulator and pump governor can, and some say should, be considered as separate and independent of the combustion control.

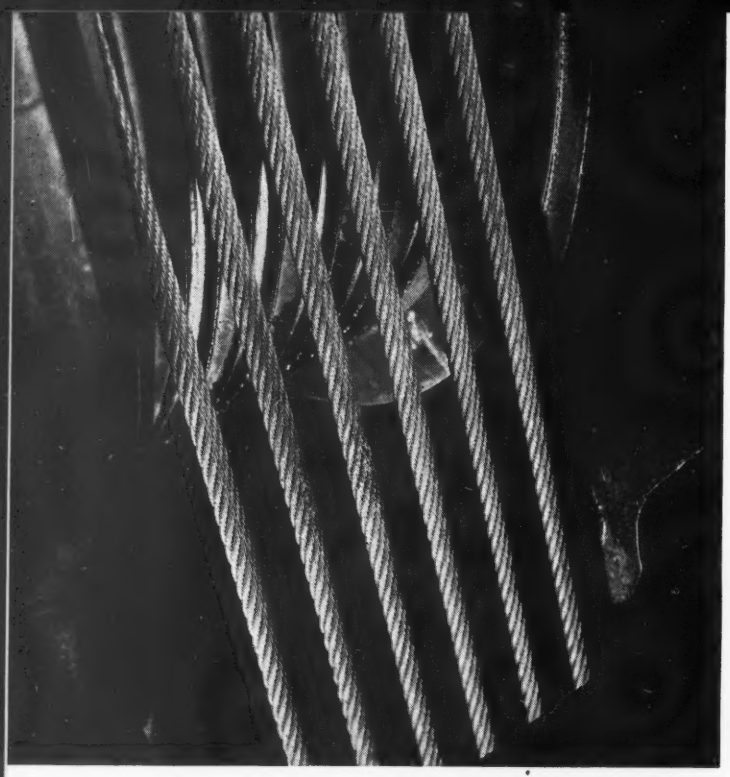
New Storage Battery

A STORAGE BATTERY, as is well known, operates because the chemical reaction is reversible. In one type, for example, discharge produces lead sulfate in the plates, and charging returns the sulfate radical to the electrolyte whose specific gravity is thus increased, hence a higher hydrometer reading. Water in the cells is electrolyzed and more must be supplied.

Different materials are used in a new type of storage cell. Advantages claimed for it are saving of space and weight (same capacity with one-third volume and one-fifth weight of a lead cell), no evolution of gas, no liquids to be added, no spontaneous discharge (so indefinite shelf life), and no permanent damage if a short circuit brings about complete discharge. Recharging is rapid. Disadvantatges are that the cell must be started by heating (from an outside source) and heavily insulated because it operates at a temperature of about 850 degrees F.

Chemical action of this new storage unit is the transfer of oxygen from one of the constituents to the other or vice versa. (Oxygen transfer occurs in lead cells, too.) A manganese dioxide and sodium nitrate mixture forms the bottom of the cell; the top part is metallic sodium. Glass wool insulation keeps in the heat. When the terminals are connected (after the cells is heated) the oxygen leaves the MNO_2 and $NaNO_3$ and oxidizes the metallic sodium. Recharging drives it back. Enough energy turns into heat to keep the cell operating as long as the terminals are connected.

Storage cells of this type may be as small and neat as the ordinary dry cells used in flashlights, or units of batteries big enough to drive a truck. Recommended applications, because of savings in cost, size, and weight, are for submarines (mileage estimated from 60 to 250), mine locomotives, railroad cars (for the lighting and air conditioning), and all sorts of electrically driven trucks and busses. An electric cigar lighter will give enough heat to start a small cell. The big batteries are heated by plugging in resistors placed between the cells.—*Research and Invention.*



Increased Service From Elevator Cables

Precautions to be taken by engineers in charge of elevator operation.

By F. L. SPANGLER

ELEVATOR cable life depends to a great extent upon the load placed upon it and the care with which it is installed and used. Because of the high speeds of travel and rapid speed changes demanded by modern elevator service, hoisting cables have a tendency to slacken at the "off" side of the traction sheave when the car accelerates, and to slacken at the "on" side when the car is brought to a stop. This action produces alternating stresses in the cable and promotes whipping. This situation applies similarly to both compensating and governor cables although to a lesser degree. Heavy load on the cables tends to correct this condition since it increases the static friction between the cables and the sheaves with the result that slippage of the cables on the sheaves is reduced, thereby reducing wear.

Internal Friction

While there is some internal friction (between the individual wires of a cable strand, as well as between the strands themselves) the principal wear in elevator cables is confined to the crown wires, those outside wires of each strand which come in contact with sheave grooves. This surface wear is one of the contributing factors to the breaking of crown wires, but elevator cables are seldom condemned because of surface wear. Cable condemnation is invariably predicated on the number of broken wires in the length of a lay, and broken crown wires in elevator cable result from bending fatigue rather than surface wear. Broken wires are easily discerned, since the broken ends "porcupine" or stand out from non-preformed cables; with preformed cable, wire breaks are detected by running a piece of waste along the cable, the waste being snagged by the ends of the broken wires even though they remain flat and in place.

Few wires in elevator cables ever wear through. They break as the result of the bending to which they are subjected. If we grasp a single wire with both hands and bend it back and forth, the wire will presently break at the point of greatest bending. This break is brought about by metallic fatigue.

A cable is a complex structure composed of many single wires, but it is subject to fatigue much the same as a single wire. The number of bends necessary to produce fatigue may run into the millions, instead of a relatively few bends, but the principle remains the same. The number of bends necessary to fatigue wire rope to the point of breakage depends upon the magnitude and nature of the stresses, diameter of the sheaves, construction of the cable, etc.

For every kind of wire there is a given value of stress which if exceeded will eventually produce failure through fatigue. This stress limit is more likely to be exceeded in non-preformed cable, in which there are high locked up stresses, than in preformed cable in which the static stresses have been relieved at the time of manufacture.

Large Sheaves Reduce Binding Stresses

Bending stresses occur in the cable every time its shape is changed, for example, at those points where the cable is passing onto and off of a sheave. If the sheave is large in diameter the bending stresses may not be great enough to cause serious fatigue regardless of how many thousand times the bending cycle occurs. On the other hand a small sheave will set up destructive fatigue (to a cable of the same size) because it introduces large bending stresses, so large indeed that it forces the cable to endure a constructional change as it travels over the sheaves.

Reverse bends are particularly severe in setting up fatigue because in addition to instituting twice the number of fatigue stresses they also introduce a reverse action which is especially severe. Wherever possible the elimination of reverse bends and the use of large diameter sheaves will greatly add to the life of cables. When

such conditions cannot be avoided, however, the use of preformed cable invariably affords longer service life since that type of cable has high fatigue resistance and can longer endure the action of small diameter sheaves without becoming permanently deformed.

While ordinarily there is relatively small surface wear to elevator cables since, when properly installed, friction is not a serious factor, it yet remains that there are factors which contribute to surface wear which should be corrected in the interest of longer cable service.

Cable and Sheave Should Fit

Probably the most serious factor contributing to surface wear is the condition of the sheaves over which the cable travels. Every cable should fit snugly in the sheave grooves without binding. A sheave with a groove too large for the cable is one which will have a pronounced tendency to flatten the rope, thus distorting its contour and shortening its life. A sheave in which the groove is too small for the cable will pinch and crush the rope and may easily reduce the life of the cable in half. Generally speaking, building engineers and elevator inspectors do not gage sheave treads or inspect the groove contour frequently enough. This is a mechanical neglect which frequently results in shortened cable life.

There are two common reasons why the contour of a sheave tread should become distorted. Entirely too often a new cable is put on an old sheave without proper sheave tread gaging. Upon the retirement of an elevator cable it is only natural that one should expect surface wear to have obtained with the result that the old cable is of smaller diameter than the new cable, also that the diameter has been reduced somewhat by stretching. This old cable having run over the sheave for many months or even years will have worn the sheave groove down to a point where the sheave will fit the old cable, but will be entirely too narrow for the new cable. This forces the new cable on a sheave which pinches it and very materially reduces its service life. When cables are retired sheave grooves should be carefully checked and very frequently turned down or "dressed" to correct the contour before the new cable is installed.

Sheave Tread Wear

The twisting or rotating of the cable as it passes over a sheave is another factor responsible for sheave tread wear. This twisting or rotating action is more commonly found in non-preformed cable and is caused by the internal torsional stresses locked up within the cable at the time of manufacture. The cable, being forced to endure these internal stresses, squirm in resistance to them as they pass over the sheave and that squirming or rotating action becomes an abrasive agent which grinds away not only the rope but the sheave tread. Up to the present time about the only method known to correct cable rotation or twisting in sheave grooves is the employment of the preformed type of cable which, having had internal torsional stress eliminated by the preforming process, has a far greater tendency to run straight and smooth over sheaves without twisting or destructive rotation.

Hoisting cables, because of the greater loads imposed upon them, ordinarily have a longer average life than the relatively light loads imposed upon compensating or governor cables. Serious wear, however, may occur to hoisting cables when the load is not evenly distributed to all ropes. Most modern elevator installations employ equalizers to distribute the load exactly to all cables and these do much to lengthen hoist cable life. Here again, however, may be found the damaging effect of sheave grooves, for an uneven depth of grooves in the traction sheaves caused by uneven wear invariably results in an inequality of load on the cables. The cable in the deep groove will not reeve as rapidly as will the one in the shallow groove and will therefore tend to slack on the "on" side of the sheave while the other cable will be taut. This difference may be compensated for to some extent by slippage of one or both cables in the groove, but of course this results in further surface wear.

Whipping, Shackles, Car Handling

Whipping or excessive vibration of elevator cables is far more than an annoyance, it is a factor of extreme importance to cable life. Whipping is especially destructive when it occurs near either end of the cable where it is fastened to shackles since it is at this point that the greatest amount of metallic fatigue is developed. The vibration set up by a long length of cable is arrested at the point of shackling and it is at this point of vibration silencing that metallic crystallization sets up and cable failure most readily becomes apparent. Here again the adoption of preformed cable will, in large measure, correct this condition because the absence of internal torsional stress from within the wires permits such cable to run freely and with greater flexibility and with much greater resistance to whipping.

Many cable failures at the shackles are due, however, to improper installation of the shackles themselves. Applying a socket or shackle to the end of an elevator cable is much more of an art than is commonly supposed and a job that a great many inadequately trained men will tackle cheerfully. There are full and complete instructions for the shackling of elevator cable available from any wire rope manufacturer or elevator manufacturer, and these instructions should be followed to the letter.

The skill of the car operator has a decided effect on the life of elevator cable. Every time an operator overruns the floor landing, requiring that the car be inched in reverse to bring it to the floor level, effects three changes in stresses instead of one. Since fatigue is hastened by the increase in frequency of bending stresses the jockeying of the car at floor landings is certain to reduce the life of cables. Automatic leveling devices do much to promote longer cable life by eliminating the need for jockeying or "inching" the car.

There is probably no piece of building equipment more neglected and abused than elevators. More frequent and much more careful inspection of all pieces of equipment, together with the installation of cables which have high fatigue resistance, will do much to lengthen cable service.

Power Plant Instruments and Records

Part II*. Routine of meter reading, recording of operating results, calculation of daily and monthly reports

By RICHARD W. CRAIN,

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READINGS of the instruments in Table II, page 388 of the June issue and the records kept will be shown by going through the routines of the meter readers. The fireman uses a record sheet as shown in Fig. 1 herewith to put down his readings for each hour. After each hour's readings he copies them down on the permanent daily log, Fig. 3. The fireman's first two readings are taken off of the turbine panel, Fig. 4. These are turbine steam meter and the feedwater readings from their appropriate integrators. The turbine steam is in pounds of steam used by the turbine, and the feedwater is in pounds of feedwater going into the boiler. On the boiler panel, Fig. 5, is read all the factors of combustion from the multi-point indicator for the boiler in operation. These readings are CO_2 per cent, drafts, in inches of water, in last pass, furnace, plenum chambers No. 1 and No. 2, and forced draft. Then is read, from the integrator for the boiler which is on the line, the steam reading, in pounds of steam coming from the boiler; and the flue gas temperature from the six-pen chart.

The make-up water meter is read along with the altitude gage board, pounds of water, which is the amount of water that is in the surge tank at the top of the building. This amount of water must be determined so that the difference in readings between midnight and midnight may be applied to the meter reading difference to get the actual amount of make-up water used during the day. From the front of the boiler, the saturated steam pressure is read. The superheated steam pressure is read from a gage in the main steam loopheader, Fig. 6, and the temperature of the superheated steam is taken at the top of the boiler just as it leaves the superheater and enters the main steam line. The induced draft fan is regulated in speed by a hydraulic coupling, and the oil in and out of the coupling is checked for its temperature.

In the basement the temperature of the inlet air to the forced draft fan is read. Down here also is read the feedwater pressures on the suction and discharge ends of the boiler feed pumps. On the main operating floor, situated on the feedwater heaters, are read bleed steam pressures on low pressure line, high pressure, and reduced high pressure. Likewise, the bleed steam temperatures for the lines are read. Also readings are taken of the condensate temperatures on the inter-after line coming in from the inter-after condensers on the air ejector, on the low pressure condensate after it has passed through the low pressure or bottom heater, and on the high pressure condensate after it has left the top or high pressure heater (this temperature being the feedwater temperature on the daily log sheet).

The weigh larry is filled with coal from the storage bin, the weight measured out being stamped on a card shown in Fig. 7. At the end of each shift the stoker bunkers are completely filled, the weigh larry chute closed and contents weighed. The amount of coal left in the larry is stamped on the card as shown in Fig. 7, and subtracted from the original weight of the last load to get the net amount of coal used in the last period of time. This last amount is entered on the log sheet for the hour of the beginning of the next shift. In case of any hour that the larry is not refilled, that hour on the Daily Log Sheet is filled in "none" for amount of coal used. See Fig. 3.

Operator's Reports

The readings the operator takes are shown on his meter record sheet, Fig. 2. After each hour's readings, like the fireman, he, too, copies his readings down on

*Part I of this two-part series was published in the June, 1939, issue of Power Plant Engineering.

TUR ST. METER	F. W. IN	INLET AIR.	F. W. OUT	BLEED ST. TEMPS. L. P.	H. P.	R.H.P.	I. A.	L. P.	H. P.

BLEED ST. PRESS. L. P.	H. P.	R.H.P.	ST. RDG.	F. W. RDG.	ST. PRESS. SAT.	S. H.	ST. TEMP. S. H.	FLUE GAS

FORCED DRAFT	P. C. 1	P. C. 2	FURNACE	LAST PASS	% CO_2	MAKEUP	SURGE TANK	HDY. COUP. IN	HDY. COUP. OUT

Fig. 1. Readings taken hourly by the fireman are recorded each shift in the columns under the headings given here

TOTAL KWH	HOUSE KWH.	NO. 1 FDR.	NO. 2 FDR.	NO. 3 FDR.	NO. 4 FDR.	IND. METER	REC. METER	VOLTS A.C.	VOLTS D.C.	CYC.	P.F.

AMPS. A.C. 1	2	3	AMPS. D.C.	GEN. TEMP.	HOUSE FDR. 1	2	3	NO. 1 FDR. 1	2	3	NO. 2 FDR. 1	2	3	NO. 3 FDR. 1	2	3	NO. 4 FDR 1	2	3

CIRC. PRESS. IN	CIRC. PRESS. OUT	CIRC. TEMP. IN	CIRC. TEMP. OUT	COND. METER	COND. PRESS. OUT	THROTTLE PRESS.	THROTTLE TEMP.	EXH.

OIL COOLERS IN	OIL COOLERS OUT	OIL COOLERS H2O OUT	CIRC. FLOW	AIR COOLERS IN	AIR COOLERS OUT	AIR COOLERS H2O OUT	BAR.	VAC.	CITY H2O METER

Fig. 2. Operator records instrument readings taken hourly on report turned in for each shift. Column headings only given here

CHICAGO, AUGUST, 1939

TIME	GENERATION					DISTR. OF PLANT OUTPUT					15 MIN KW. DEMAND	A.C. VOLTS	POWER FACTOR	FREQ.	TIME ERROR		GENERATOR							FEEDER CIRCUITS								
	GEN. NO.1		GEN. NO.2		TOTAL KWH.	HOUSE FEEDER		NET KWH.	FOR NO. 1	FOR NO. 2							A.C. AMPERES			D.C.		IND. KW.	GEN. TEMP.	A.C. AMPERES			A.C. AMPERES			A.C. AMPERES		
	RDG.	KWH.	RDG.	KWH.		RDG.	KWH.		RDG.	RDG.					F	S	1	2	3	VOLTS	AMPS.			1	2	3	1	2	3	1	2	3
12 M																																
1 A.M.																																
2						A					B								C						D							
10																																
11																																
12 M																																

TURBINE — CONDENSER — HEATERS

TIME	FLUID FLOWS				PRESSURES									TEMPERATURES																	
	STEAM RDG.	CONDENSATE		G. WATER G.P.M.	THROTTLE	EXHAUST			CIRC. WATER		COND.	SUCTION HEADER	BLEED STEAM			THROTTLE	EXH.	CIRC. WATER		BLEED STEAM			COND. AFTER HEATERS			OIL COOLER			AIR COOLER		
		RDG.	LB./HR.			BAROM.	VAC.	ABS.	IN	OUT			L.P.	H.P.	R.H.P.			IN	OUT	L.P.	H.P.	R.H.P.	I-A	L.P.	H.P.	OIL IN	OIL OUT	WATER OUT	AIR IN	AIR OUT	WATER OUT
12 M																															
1 A.M.																															
2																															
													F-1, F-2 & F-3																			
10																															
11																															
12 M																															

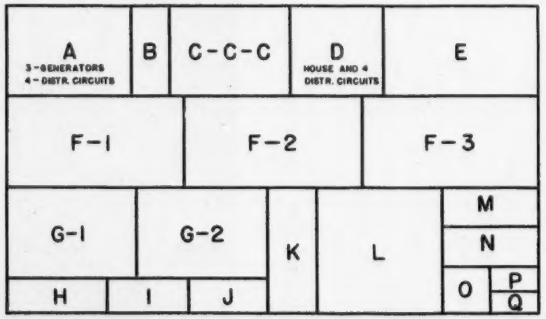
STEAM GENERATORS

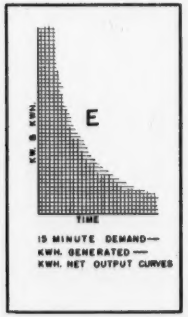
TIME	FLUID FLOWS			PRESSURES		TEMPERATURES						DRAFTS					% CO_2	LB. COAL WEIGHED	CITY WATER				MAKE UP		SURGE	ACTUAL
	STEAM RDG	FEEDWATER		STEAM	FEED WATER	STEAM		INLET AIR	FLUE GAS	HYD. CPLG. OIL		FORCED	P.C. NO.1	P.C. NO.2	FURNACE	LAST PASS			RDG.	GAL.	RDG.	GAL.	TOTAL GAL.	RDG.	LB./HR.	TANK LB	MAKE UP LB.
		RDG.	LB./HR.	SAT.	S.H.		F.W.	S.H.			TO COOLER	FROM COOLER															
12 M																											
1 A.M.																											
2																											
								G-1 & G-2																K			
10																											
11																											
12 M																											

SUPPLIES	LIGNITE COAL	STORAGE COAL	TURBINE OIL	CRANK CASE OIL	BEARING OIL
ON HAND 12 M	LBS.	LBS.	GAL.	QTS.	QTS.
RECEIVED DURING DAY	LBS.	LBS.	GAL.	QTS.	QTS.
TOTAL	LBS.	LBS.	GAL.	QTS.	QTS.
USED DURING DAY	LBS.	H LBS.	GAL.	QTS.	QTS.
NET REMAINING 12 M	LBS.	LBS.	GAL.	QTS.	QTS.
ORDERED: QUANTITY TO BE DELIVERED					

CIRCUIT OUTAGES									FEEDER CIRCUITS OPENED				
FOR.	OUT	IN	OUT	IN	OUT	IN	OUT	CALLED	CIRCUIT	TIME OPENED	ORDERED OPEN BY	TIME CLOSED	ORDERED CLOSED BY
				I							J		

FIG. 3 LOG OF DAILY OPERATION.
AT THE BOTTOM CENTER IS A PLOT SHOWING LAYOUT OF SECTIONS ON THE DAILY LOG WHICH IS MADE ON A SHEET 22 BY 36 IN. SECTIONS ARE LETTERED HERE TO INDICATE LOCATIONS ON LAYOUT AND ALL COLUMN HEADINGS ARE GIVEN.





EQUIPMENT	OPERATED							
TIME	12	1	2	10	11	12	IN SERVICE HR.	IN SERVICE MIN.	AVAILABLE HR.	AVAILABLE MIN.
TURBO - GEN. NO. 1										
TURBO - GEN. NO. 2										
TURBO - GEN. NO. 3										
STEAM GEN. NO. 1										
STEAM GEN. NO. 2										
BLR. FD. PUMP NO. 1										
BLR. FD. PUMP NO. 2										
BLR. FD. PUMP NO. 3										
COND. PUMP NO. 1										
COND. PUMP NO. 2										
COND. PUMP NO. 3										
COND. PUMP NO. 4										
COND. PUMP NO. 5										
COND PUMP NO. 6										
CIRC. WATER PUMP NO. 1										
CIRC. WATER PUMP NO. 2										
CIRC. WATER PUMP NO. 3										
CIRC. WATER PUMP NO. 4										
CIRC. WATER PUMP NO. 5										
COOLING TOWER FAN NO. 1										
COOLING TOWER FAN NO. 2										
COOLING TOWER FAN NO. 3			L							
COOLING TOWER FAN NO. 4										
COOLING TOWER FAN NO. 5										
FORCE DRAFT FAN NO. 2										
IND. DRAFT FAN NO. 1										
IND DRAFT FAN NO. 2										
INST. AIR COMP.										
MAIN AIR COMP.										
HOUSE SERVICE PUMP										
EMERGENCY GEN.										
TRANSFER BREAKER										
RIVER PUMP NO. 1										
RIVER PUMP NO. 2										
GRATES DUMPED NO.1-S										
GRATES DUMPED NO.1-N										
GRATES DUMPED NO.2-S										
GRATES DUMPED NO.2-N										
ASHES SLUICED										
STOKER NO.1 GREASED										
STOKER NO.2 GREASED										
BOILERS ON HAND CONTROL										

MAINTENANCE REMARKS

SHIFT 1

SHIFT 2 — M

SHIFT 3

GENERAL REMARKS

SHIFT 1

SHIFT 2 — N

SHIFT 3

12M 7AM 12N 7PM

DRY BULB

WET BULB — O

WEATHER

PREVIOUS MAX. 15 MIN. PEAK ____ KW.

PREVIOUS MAX. DAILY GEN. ____ KWH.

PREVIOUS MAX. DAILY NET OUTPUT ____ KWH.

SHIFT 1 OPERATOR

SHIFT 1 FIREMAN

SHIFT 2 OPERATOR — P

SHIFT 2 FIREMAN

SHIFT 3 OPERATOR

SHIFT 3 FIREMAN

CHECKED BY ____ CHIEF OPERATOR

COMMENTS: — Q

DAY OF WEEK

DATE

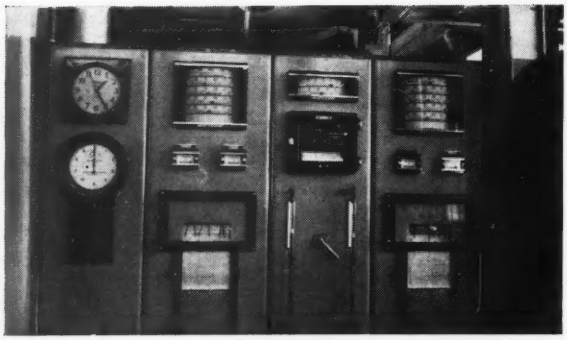


Fig. 4. Turbine panel board

the permanent daily log, Fig. 3. From the turbine panel, shown in Fig. 4, the circulating water flow in gallons per minute and the exhaust steam temperature from the six-pen chart for the unit operating, the barometer and vacuum on the condenser from the two mercury columns are read. The difference between the barometer and the condenser vacuum readings is the absolute vacuum which is recorded on the permanent daily log. If this absolute vacuum gets above 1.18 in. of mercury, meaning that the condenser vacuum is too low because of too warm circulating water, another circulating pump is put on and a couple of cooling tower fans, unless they are already on. This, then, sends more and cooler circulating water through the condenser, more thoroughly condensing the steam and raising the vacuum which lowers the absolute vacuum. It is best at about 1 in. of mercury.

From gages on the turbine, the throttle pressure and temperature are read. These are the pressure and temperature of the steam at the turbine throttle valve. In the basement are read the circulating water pressures

Fig. 5. Boiler panel board

and temperatures in and out of the condenser, the condensate pressure at the discharge of the condensate pump, the temperature of the air in and out of the generator air cooler, the temperature of the circulating water coming out of the generator air coolers and the turbine oil coolers, the condensate meter which gives the number of pounds of boiler feedwater used, and the city water meter.

On the operating floor again, the rest of the operator's readings are taken. These are on the electrical panel board, Fig. 8, and are the kw-hr., amperes, volts, generator temperature, cycles, power factor, etc., for the generator being used, the house load, and the four city circuits. The data reading sheet, Fig. 2, and the daily log sheet, Fig. 3, show all these readings plainly.

The kw. load on the generator is watched, for at times it swings badly and the cycles might get too fast or too slow. The cycles are kept at 60 by means of an operating handle on the electrical panel board. This handle is turned to increase or decrease the number of cycles, in doing so it operates a small motor on the side of the governor on the turbine—the motor regulates the number of cycles by changing the generator speed. Just over the cycle indicator is the a.c. volt indicator. This is kept at 2500 by a hand-controlled rheostat. There is also a recording meter for these a.c. volts. The load will also affect the master clock, so in keeping the cycles adjusted, the master clock is kept on zero. This keeps all the electric clocks in town on time. Every

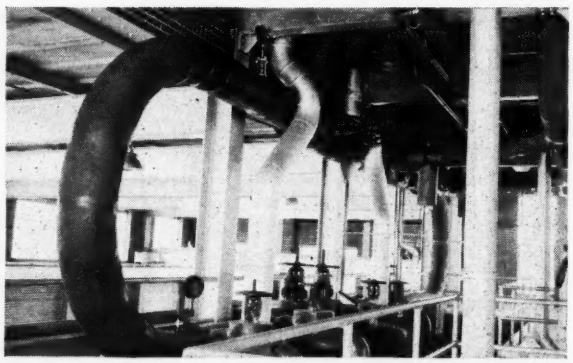


Fig. 6. Main high-pressure steam loop header

day the Arlington time signal is obtained over the radio so as to correct the master clock should it be different from the telechron second hand which is caught by the eye as the time signal is given.

Daily Operating Log

The record system in this plant consists of four steps. The first step has been outlined above. That was the reading of all instruments and recording them on the temporary sheets of the fireman and operator, Figs. 1 and 2. Then comes the copying of the above readings on to the permanent "Log of Daily Operations", Fig. 3. On this log all readings taken for 24 hr. are recorded. In the upper right hand corner (E) are drawn three load curves showing in purple the kw-hr. generated, in red the kw-hr. net output, and in green the 15 minute demand (recorder on electrical panel). In the "Equipment Operated" space (L) at the bottom of the log, straight lines are drawn beside

WEIGHED ON FAIRBANKS TYPE-REGISTERING BEAM

LOAD OF _____ DATE _____ 19__

BOUGHT OF _____

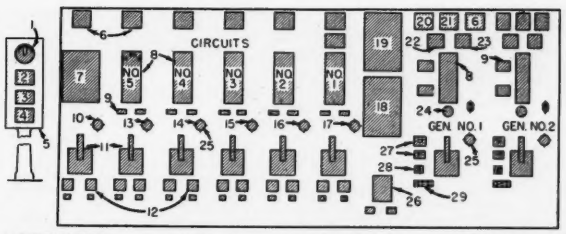
GROSS _____ LBS. PRICE _____ PER CWT.

TARE _____ LBS. PRICE _____ PER BU.

NET _____ LBS. DRIVER _____ ON OFF.

NET _____ BU. _____ WEIGHER

Fig. 7. Scales stamp coal weight card, with carbon copy duplicate



1 - SYNCHROSCOPE
2 - A.C. VOLTS NO.1
3 - A.C. VOLTS NO.2
4 - CYCLES
5 - AT RIGHT ANGLES TO ELEC. SWITCHBOARD AT LEFT END
6 - A.C. AMPS.
7 - VOLTAGE RECORDER
8 - K.W.H. METER
9 - TEST BLOCKS
10 - BUS TRANSFER
11 - OPERATING LEVER & CIRCUIT BREAKER
12 - CURRENT RELAYS
13 - PLANT TRANS.
14 - EAST RESIDENCE
15 - EAST BUSINESS
16 - WEST BUSINESS
17 - WEST RESIDENCE REGULATOR
18 - RHEOSTAT FOR A.C. VOLTAGE NO.1
19 - RHEOSTAT FOR A.C. VOLTAGE NO.2
20 - GEN. TEMP.
21 - A.C. KW. INDICATOR
22 - D.C. VOLTS
23 - D.C. AMPS.
24 - VOLTAGE SPEED
25 - PH. CURRENT CONTACTOR
26 - K.W. REC. METER
27 - SYNCHRONISM SW.
28 - GEN. SPEED (CYCLES, R.P.M.) REGULATOR
29 - TEMP. PLUGS FOR GENERATOR

Fig. 8. Location of instruments on electrical switchboard

the apparatus being used through the hours of use. Other miscellaneous data as weather, coal on hand, maintenance remarks, etc., are shown on the log. Each fireman and operator sign the log on his shift.

Summary of Daily Operations

The next step in record procedure is the "Summary of Daily Operations", this record blank being shown in Fig. 9. Using a comptometer all readings are averaged and placed on this sheet. Percentages are calculated, fuel consumption and steam used per kw-hr., boiler efficiency, and other vital figures are recorded as is shown in the figure. Referring to Fig. 9, numbering the items down, an example of how the sheet is filled in follows:

1. Kw-hr. Generated ..... From Log Sheet
2. Kw-hr. to House Service ..... From Log Sheet
3. Kw-hr. Net Output ..... Subtract above two (1-2)*
4. Pounds Condensate ..... From Log Sheet
5. Pounds Make-Up ..... From Log Sheet
6. Pounds Evaporated ..... From Log Sheet
7. Per cent Make-Up ..... $\frac{100 \times \text{lb. make-up}}{\text{lb. condensate}}$; $\frac{100 \times (5)}{(4)}$

SUMMARY OF DAILY OPERATIONS
LIGHT AND POWER DEPARTMENT — CITY OF FORT COLLINS, COLO.

Date..... Day of Week.....

	SHIFT 1	SHIFT 2	SHIFT 3	TOTAL 24 Hrs.
KWH Generated (Gross)				
KWH to House Service				
KWH Net Output				
Pounds Condensate				
" Make Up				
" Evaporated				
Percent Make Up				
Pounds Coal Consumed				
Approx. BTU / lb. as fired				
Pounds Steam per pound coal				
" " " KWH Gen.				
" " " " Net Output				
" Coal " " Gen.				
" " " " Net Output				
Average Steam Pressure at Boiler				
" " " Temp. at S. H. Outlet				
" " " Feed Water Temp.				
" " " BTU added per pound steam				
" " " Consumed per pound steam				
" " " percent efficiency, steam generator				
" BTU consumed per gross KWH				
" " " " " net "				
Average KWH per Hour				
Maximum " " "				
Minimum " " "				
Average Exhaust Press., Inches Hg.				
" Circ. Water Temp.				
" " " Flow GPM				
Average Stack Temp.				
" Air "				
Remarks: Chief Operator.				

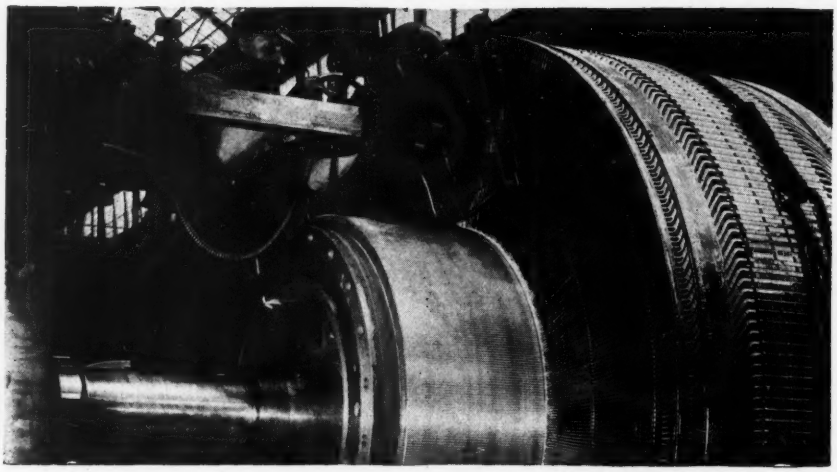
Fig. 9. Form used to report summary of daily and monthly operations

8. Pounds Coal consumed ..... From Log Sheet
9. Approx. B.t.u. per lb. as fired ..... 9350 Ave.
10. Pounds steam per pound coal ..... $\frac{\text{lb. condensate}}{\text{lb. coal consumed}}$; $\frac{(4)}{(8)}$
11. Pounds steam per kw-hr. Generated ..... $\frac{\text{lb. condensate—lb. steam used by ejectors in 24 hr. (4320, 180 lb. per hr.)}}{\text{kw-hr. gen.}}$
12. Pounds steam per kw-hr. Net Output ..... $\frac{\text{lb. condensate—4320}}{\text{Net kw-hr.}}$; $\frac{(4)—4320}{(3)}$
13. Pounds coal per kw-hr. gen. ..... $\frac{\text{lb. coal consumed}}{\text{kw-hr. gen.}}$; $\frac{(8)}{(1)}$
14. Pounds coal per kw-hr. Net output. ..... $\frac{\text{lb. coal consumed}}{\text{Net kw-hr.}}$; $\frac{(8)}{(3)}$
15. Average Steam Pressure at Boiler ..... From Log Sheet
16. Average Steam Temp. at S. H. Outlet ..... From Log Sheet
17. Average Feedwater Temp. ..... From Log Sheet
18. Average B.t.u. added per lb. steam .. Molier steam chart, at Ave. steam pr. and temp., minus heat of liquid at f.w. temp. (15 and 16-17)
19. Average B.t.u. consumed per lb. steam ..... $\frac{\text{lb. coal (per hr.} \times \text{heat value 9350)}}{\text{lb. condensate per hr.}}$; $\frac{\frac{(8)}{24\text{ hr.}} \times 9350}{\frac{(4)}{24\text{ hr.}}}$
20. Per cent Eff., Steam generator ..... $100 \times \frac{\text{lb. cond. per hr.} \times \text{B.t.u. added per lb. st.}}{\text{lb. coal per hr.} \times \text{heat value (9350)}}$; $100 \times \frac{\frac{(4)}{24\text{ hr.}} \times (18)}{\frac{(8)}{24\text{ hr.}} \times 9350}$
Check Eff. ..... $\frac{\text{Heat added per lb. st.}}{\text{Ave. B.t.u. consumed per lb. st.}}$; $\frac{(18)}{(19)}$
21. Average B.t.u. consumed per Gross kw-hr. ..... $\text{lb. coal per hr.} \times \text{heat value (9350)}$; $\frac{\frac{(8)}{24\text{ hr.}} \times 9350}{\frac{(1)}{24\text{ hr.}}}$
22. Average B.t.u. consumed per Net kw-hr. ..... $\text{lb. coal per hr.} \times \text{heat value (9350)}$; $\frac{\frac{(8)}{24\text{ hr.}} \times 9350}{\frac{(3)}{24\text{ hr.}}}$
23. Average kw-hr. per hour ..... $\frac{\text{kw-hr. gen.}}{24\text{ hr.}}$; $\frac{(1)}{24\text{ hr.}}$
24. Maximum kw-hr. per hour ..... From Log Sheet
25. Minimum kw-hr. per hour ..... From Log Sheet
26. Ave. Exhaust Press in. Hg. ..... From Log Sheet
27. Ave. Circ. water temp. ..... From Log Sheet
28. Ave. Circ. water flow g.p.m. ..... From Log Sheet
29. Ave. stack temp. ..... From Log Sheet
30. Ave. air temp. ..... From Log Sheet

*Numbers in parentheses refer to items in this summary.

Monthly Summary

The fourth and last record step is at the end of the month when a summary for the month is made up. This merely averages the items in all the daily summaries for the month, except the kw-hr. readings which are totaled, and the same blank, Fig. 9, is used.



Undercutting a large Commutator

How To Tighten a Commutator

By J. S. WILLIAMS
Service Division, Westinghouse Electric & Mfg. Co.

THE COMMUTATOR is the heart of the direct current motor. Under the best of conditions the commutator has to perform a difficult and exacting function and it must be treated as a vital part of a motor because poor materials and poor workmanship in either manufacture or assemblage eventually lead to operating troubles that are annoying and costly.

It is essential to heat a commutator to a maximum of 105 deg. C. if the armature is wound and 150 deg. C maximum if the core is bare, before attempting to tighten a commutator. The bond in the mica is hard when cold and tends to pulverize when the commutator is tightened cold. If the commutator is heated, the bond softens, allowing the mica parts to become pliable and conform to the irregularities of the metal parts during the tightening operation.

One of the major functions of the bond is to cover the entire surface of each mica splitting to eliminate pockets where oil and moisture may collect. Then if the bond is pulverized, due to cold tightening of the commutator, it makes oil absorption of the mica v-ring at such points relatively easy.

Heat Commutator in Oven

The commutator is best heated in an oven if one is available. The temperature should be measured with the thermometer on the copper bars. It is dangerous to guess at the temperature of the commutator.

When heating a commutator with a torch, play the flame preferably on the steel parts of the commutator core as the steel parts will retain the heat long enough to allow time for tightening the commutator. Do not apply heat exclusively to the copper parts because they radiate the heat so rapidly that the commutator cools before the tightening operation is completed.

Heating a commutator with the flame directly on the copper should be avoided because it tends to over-heat the bars at spots, thereby reducing the hardness. These soft spots will wear faster than the rest of the commutator causing flat spots.

Commutators for general purpose motors are designed to be tightened by applying a pressure up to 30 tons from a suitable press to the front steel v-ring, using the ring nut or bolts to retain the pressure. The standard wheel press is available in most repair shops and can be rigged up to supply the necessary pressure. The armature is supported in a wide belt.

Use Wrench to Tighten Commutator

A simple commutator wrench is used to apply the pressure to the steel v-ring and at the same time perform the tightening operation. This wrench consists of two rings, namely the outer ring which is used to transmit the pressure from the press to the steel v-ring and the inner ring to tighten the commutator nut so that it will retain the applied pressure.

The outer ring is made from steel plate formed into a circle whose inside diameter is slightly larger than the ring nut of the commutator, the seam being welded. The solid end of the ring fits against the commutator steel v-ring while the end next to the press has an opening of approximately 80 deg. for the wrench handle to operate in.

The outside diameter of the inner ring is slightly smaller than the inside diameter of the outer ring so that it slides through without binding. The end next to the commutator ring nut is drilled for two dowel pins 180 deg. apart which fit into the dowel holes in the com-

mutator nut. Two holes are drilled through the ring, 90 deg. from the dowel pins for through bolts, to bolt the ring to the commutator nut. These holes must be larger than the bolts so that the dowels and not the bolts will take the tightening pressure of the wrench handle. The other end of the ring is slotted every 60 deg. for the wrench handle to fit into. The inner ring is drilled and pins are driven into the ring instead of the rings being slotted.

If the commutator to be tightened is of the bolted type the inner ring is not necessary. The pressure is applied to the steel v-ring by the outer ring and the bolts are tightened by a ratchet wrench.

It is more convenient to work on a commutator during the tightening operation when the armature is in a vertical position. Then as each part is assembled in its sequence of assembly, it will stay put.

The following general specifications should be used for repairing all commutators:

(A) Replacing Assembled Segments

(1) Disassemble commutator. (Use press and wrenches to remove ring nut.)
(2) Clean metal parts thoroughly.
(3) Make sure commutator nut turns on easy the entire length of the thread.
(4) Clean mica "V" Ring with sand paper and place in position. Do not touch part which enters copper "V" with fingers after cleaning.
(5) Clean out the "V'S" of the assembly segments with sand paper and check for short circuits between bars with 500 v. and paint "V'S" with a thin coat of shellac.
(6) Place the armature in a vertical position and assemble rear mica "V" ring and assembled segment.
(7) Assemble front steel and mica "V" ring.
(8) Check centerline of bars with center line of slot in core. This information must conform with the manufacturer's requirements shown on armature layout data.
(9) Tape assembled segments above and below banding wire with four turns of friction tape.
(10) Cut banding wire with file.
(11) Check parallel alinement of bars with brush.
(12) Tighten ring nut sufficiently to hold the assembly right.
(13) Heat in oven at 125 deg. C to 150 deg. C.
(14) Press and tighten commutator while hot, using 20 to 30 tons pressure, depending upon the size of the commutator.
(15) When cold test for loose bars.
(16) Give ground test of 1000 v., plus twice normal voltage of motor.
(17) Test between bars with 500 v.
All commutators opened for repairs should be assembled as outlined above.

(B) Replacing Copper Bars

To replace burned or broken copper bars use bars from an old commutator of the same design if the old bar is not worn more than the bars on the commutator it is to be used with. If no such copper bar is available, a new bar must be obtained.

To machine the new bar to fit the commutator to be used with, a pattern bar must be removed from the commutator. Place the pattern bar on the new ones and scribe the pattern on them with a sharp tool. Saw out the "V'S" of the new bars as close to the scribed line as possible.

When new copper bars are to be replaced, new mica strip must also be replaced.

Paste the copper bar to a mica strip with shellac. When dry, place in a vise and cut the "V'S" of the mica with a sharp knife—the stroke of the knife moving toward the copper bar.

Place the new bar and pattern bar, with mica strip between the bars, in a vise. File the "V'S" of the new bar to match those of the pattern bar. When this is done the "V'S" of the mica strip are also finished.

Assemble bars by following the instructions set forth in paragraph (A).

(C) Re-Micaing Commutator

When a commutator is to be refilled with new mica, the correct thickness of plate is to be used. By careful consideration the amount of scrap can be kept to a minimum by following these instructions carefully:

(1) Cut the mica plate into strips the width of the bar.
(2) Clean the surface of the bars by sanding or bright dipping.
(3) Apply a coat of pure heavy orange shellac to one side of the mica strip.
(4) Lay the copper bars on the mica strip. Allow for a $\frac{1}{16}$" rear mica extension.
(5) Place a weight on the bars while the shellac dries.
(6) Saw the strips apart as shown by the dashed lines with band saw. The throat of the saw table through which the saw passes must be as narrow as possible.
(7) Remove mica in "V'S" to rough dimension with band saw.
(8) Finish to copper V with flat knife file.
Do not remove mica strip from copper bar.
(9) Paint exposed side of mica strip with a coat of pure heavy orange shellac and assemble while wet.
(10) Tighten commutator as discussed in paragraph (A).

(D) Insulate Front Mica "V" Ring

(1) Clean exposed mica "V" ring thoroughly with sand paper.
(2) Paint with one coat of varnish.
(3) Wind, while varnish is still wet, closely around the mica "V" ring with one layer of four ply Italian Twine No. 1157, pulling ends through.
(4) Apply a heavy coat of red commutator compound over the Italian twine extending it out over the end of the steel "V" ring and the front end of the commutator bars making a large fillet at the point of intersection of the bar and the mica "V" ring. When dry it will leave a glossy finish. Do not brush while drying.

"Hot" Lightning

Fig. 1. Like natures lightning bolts, a stroke of artificial "hot lightning" demonstrates its ability to burn by setting fire to a haystack

THE FIRST PUBLIC demonstration of man-made "hot" lightning was made by Westinghouse engineers at Sharon, Pa., on May 8, 1939, simultaneous with the inauguration of an artificial lightning test for all distribution transformers of the completely self-protected class.

The improved lightning generator was able to create artificial lightning complete with the relatively low current, long-lasting "tail" that gives lightning its destructive, burning effects. The engineers let loose bolts of "hot" lightning that set afire a haystack, fused a pile of sand that instantly ignited cloth, caused an electric power pole to burst into flame. Strokes from the previous form of lightning generators, by comparison, widely scattered the hay and sand, split the pole, and pierced the fabric—without setting any of them ablaze. Distribution transformers with the latest forms of protective devices withstood the onslaught of both forms of lightning.

Tests

The "hot" lightning generator will be used by its creator Mr. P. L. Bellaschi, research engineer, in charge of the high-voltage laboratory in experiments to improve electric power apparatus.

All lightning-proof distribution transformers as they come from the production line are routed through a test room where they are subjected to direct strokes from a lightning generator. Each transformer receives its baptism of lightning by applying to each terminal a surge that rises at the rate of one and a half million volts in a millionth of a second, and is followed by the tremendous flood of current of 55,000 amp.

Lightning Has Three Components

Lightning is not just the discharge of extremely high voltage—of the order of several million volts. Natural lighting has, in effect, three components; high voltage, followed by an extremely high current for a few dozen millionths of a second, and finished with a discharge of much smaller current lasting for a much longer period of time—up to a full second.

The earliest lightning generators were simply high-voltage generators, producing a high-potential, low-current lasting for only a few microseconds. Valuable as was this laboratory development is was not a very close approach to lightning since the current associated with it is too small to develop the full effects and damage on apparatus that results from combined voltage and current.

The principal problem in the design and construction of a high-voltage high current lightning generator lay not in building a high-voltage element or a high-current element—but in hitching the two together. Some means must be had for releasing the current discharge two to ten millionths of a second after the voltage discharge is initiated. The answer was found in what is known as a micro-second switch.

The Micro-Second Switch

In its application to surge generator for production testing the micro-second switch is a fiber tube with a small hole running down its center and placed in series with the high-voltage generator. The high temperature created by breakdown of the air in this small hole vaporizes a small quantity of fiber which is expelled violently out of the hole. The tube is mounted so that the gas is discharged across the gap holding back the charge of the high-current generator. The

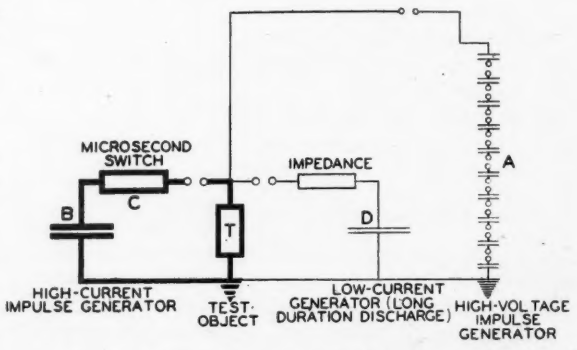


Fig. 2. Schematic diagram of the lightning generator

Used in Transformer Tests

electrical strength of this gap is greatly lowered permitting the current generator to dump its charge into the lightning circuit.

Based on the experience with the high-voltage, high-current surge generator in the laboratory Westinghouse engineers found it feasible to construct a high-current surge generator for factory use. This surge generator is located in a 35 by 10 foot two-story brick-walled room and is encircled by the conveyor system on which is routed all the completely self-protected distribution transformers. Each unit is tested in one of the generators two test booths. The generator consists of a battery of 15 capacitors charged in parallel and discharged in series to give a surge of 1,000,000 volts maximum, and a battery of 32 capacitors that can produce a discharge of 80,000 amp.

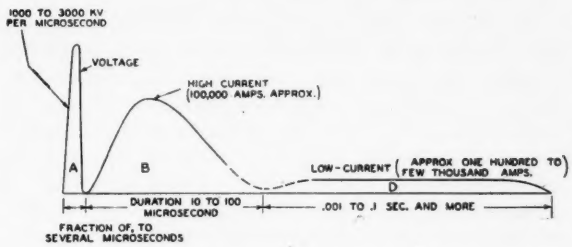


Fig. 3. Schematic representation of lightning discharge

The generator output is fed to plug-type terminals on the back wall of the two test booths and to which connection is automatically made to the unit under test as the track on which it rests is pushed into the booth. An automatic position switch connects the surge generator to the terminals of the transformer in turn, so that all terminals (each high-voltage terminal to ground, and each low-voltage line terminal to the grounded mid-point) are given identical surges. The same surge test is given all distribution transformers, of the completely-self-protected class, regardless of voltage or capacity rating.

"Hot" Lightning Is Duplicated

Although the high-voltage, high-current lightning generator as a laboratory or shop tool is fully adequate to determine the ability of most electrical insulation to withstand lightning's shocks the engineers could not be satisfied until they were able to create in the laboratory the full counterpart of lightning. This has now been done by adding the third or time element to lightning. This has been accomplished by adding a "tail", the relatively low current, but long-lasting discharge at the end of the high-current surge. The engineers have thus built up a realistic lightning surge that consists of a sharp voltage peak that rises very steeply,—of the order of one and one half million volts per microsecond, and lasting not more than a few microseconds. This is closely followed—with a delay of not more than five or ten microseconds—by the high-current discharge of some 100,000 amperes extending over a period as long as 100 microseconds. At the expiration of this surge the low-current discharge is added. The magnitude is only a fourth or less of the high-current surge but its duration may be a large fraction of a second—a thousand or more times longer than the high-current surge. The "tail" that has been added to the surge gives it the characteristics that rightfully earn for it the title "hot" lightning. A bolt from the high-current surge generator may cause breakdown of insulation, will scatter a pile of sand, will drill small clean holes in fabric, will scatter excelsior without burning it, will split a wood pole but seldom set it afire. On the other hand, "hot" lightning, if it causes breakdown of insulation at all, will more completely destroy it. It will fuse a pile of sand, cause fabric or excelsior to burst into flames, not only splits a wooden pole but sets it afire. Quickly—and approximately summarized—whereas the two types of surges are equally effective in causing an insulation failure, though "hot" lightning has an additional destructive element.

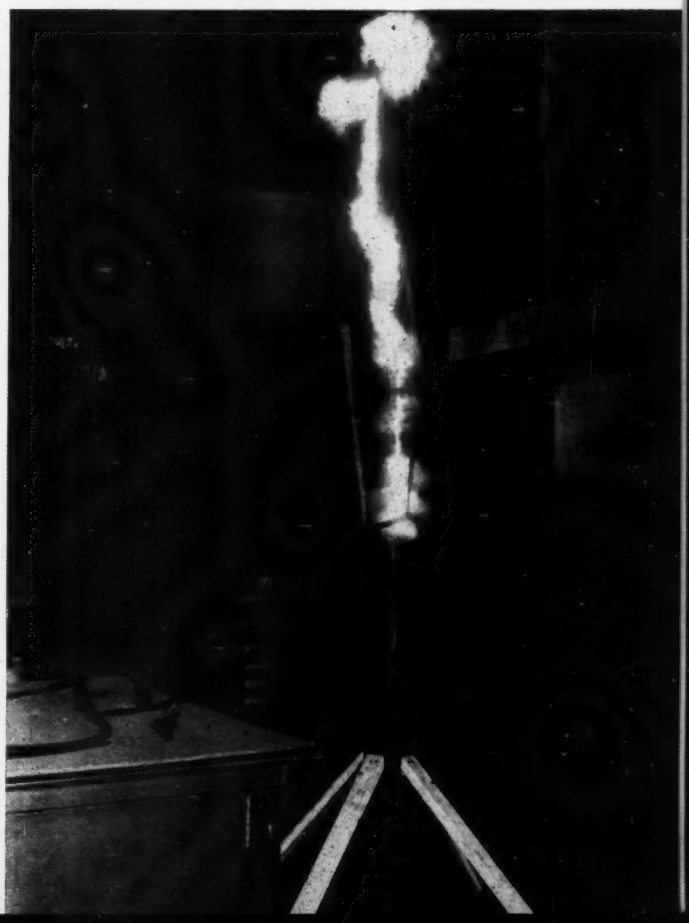


Fig. 4. Pole split by a 3,000,000 v. man made lightning stroke

Power Plant Maintenance

A Symposium

Work and Systems; Thinkers and Doers; Summer Repairs; Preventive Maintenance.

Each day the operating problems presented in a power plant are distinctively different. General principles for handling the work that are applicable in nearly every type of plant, however, can be laid down. In the four articles published here as a symposium on maintenance, the similarity of many phases of handling maintenance work is quite evident. All advocate the keeping of records of equipment; careful organization of staff and assignment of responsibilities; dependence upon operators to discover, before serious trouble develops, the trifling irregularities in the running of equipment; resort to special inspection and tests to determine the extent of defects; and immediate remedy of defects in the interest of safety and economy.

In publishing these articles at this time, the thought in mind is that many engineers do a major portion of their repair jobs during the summer and early fall months, since usual weather conditions do not interfere, load conditions, however, must govern the periods at which equipment can be taken out of service for inspection or repair. Organization and procedure have been stressed in order that those now in the midst of their summer repair work might give the ideas presented careful study and, in the light of their present problems, adjust their maintenance methods along lines that are proving highly successful in other plants. Readers are invited to enter this discussion by contributing additional ideas on this important subject of maintenance.—Editor.

Maintenance Work and a Maintenance System

By P. F. Rogers

MAINTENANCE is a broad term that covers a multitude of sins. The purpose of maintenance should be to increase the reliability of the entire plant by taking care of necessary repair and corrective work before it is absolutely necessary. As it often works out it results in taking care of the work in an emergency after a failure has occurred. As far as the actual or direct cost is concerned there may be little difference for the overtime cost of emergency work is often balanced by the increased inspection cost under a preventive system. The real cost of emergency work comes indirectly as a rule for the failure of a single machine may well tie up several departments, in fact a serious failure in the power plant may tie up the entire plant including the office if the weather happens to be cold.

Unfortunately a proper and comprehensive maintenance plan is not as easy as it sounds for several reasons. First, during depression times maintenance work is usually curtailed. Second, catching up on the slack often means increased expense temporarily just as it does when the work is taken up again after a curtailment of several months or a year. Third, and probably most important, an effective program requires planning and after the planning overcoming the first two objections by selling the plan to the management.

As a matter of fact a successful maintenance program is about 25 per cent organization and 75 per cent inspection. The success of the entire venture hangs on the experience and ability of the men responsible to spot the locations where repair work is necessary. It does not take many emergency jobs to make the management lose faith in a preventive program.

Shorted armature coils may be spotted by means of steel strap vibration test

Classification of Equipment

As the first step equipment should be classified into groups according to use or function and as a second step provision should be made for regular inspection of the equipment in each group by a competent man. In a small plant one individual may look after the inspection of all classes perhaps devoting but a few hours a week to this work. In larger plants the work may be divided between several individuals while in the very largest industrial plants the inspection may make a full time job for one individual.

Motors, starters, switches, etc., should be grouped together and the inspection should be done by a competent electrician capable of gaging and megging. Where there are considerable numbers of belt drives maintenance work on the motor bearings will usually be reduced materially by making this inspector responsible for the belt tensions. If not a report on belt tensions should be included on the inspection report.

Instruments and mechanical meters of all kinds should be grouped together. The most practical way of handling this work is to make one man responsible for changing all charts as well as inspection and maintenance work on them. As a rule this work is best intrusted to a young man with intelligence and mechanical ability, for if the job is done well it must be done by a person interested in the whys and wherefores of the instruments themselves and their use. Instruments represent a considerable investment and their readings should be accurate and reliable.

Heating System Equipment

The heating system including all radiators, traps, valves, pumps and piping should be included in one major group. In some plants it may be desirable to include all hot and cold service water lines and faucets while in others it may be desirable to include these in a separate group. As a rule it is more satisfactory to set up a separate group for all high pressure steam lines but this again depends upon local plant conditions and to a large extent upon the experience and ability of the man entrusted to do the routine inspection.

It is best to put the entire power plant and related power and service equipment such as pumps, compressors, etc., in a separate group, subdivided into electrical and mechanical. The electrical equipment can, in many cases, be taken care of by the same man who handles the motors. The qualifications of the mechanical inspector are self evident. This is no job for a low priced beginner and should be entrusted only to an experienced mechanic.

Process equipment, that is machines actively used in the different departments warrant special attention and as a rule considerable diplomacy must be exercised if friction is to be avoided with the heads of the departments. It is one thing to have them call in the repair gang to take care of a breakdown and quite another to have a mechanic poking around a machine that is apparently all right. This is especially true with machinery which requires careful adjustment and operation. It is often necessary to do the inspection at noon or after work either for safety, because a better job can be done, or to avoid interference with production.

Equipment Record

After the groupings have been made it is necessary to have a separate card or sheet for each piece of equipment as far as possible. This should include name plate data and other information thought necessary such as time installed, price, repair and inspection dates. Most well organized plants keep the data of this kind in convenient form. As a rule the paper work involved does not justify duplication of card so the most convenient method is to make an inspection card with just sufficient data on it for identification. These inspection cards can then be filed according to dates inspection is due, the two sets being cross indexed for reference. In this way the day's work for the inspector is automatically mapped out for him at the beginning of each day. It is not very practical to have a card for each piece of equipment such as valves, radiators, etc., and these piping systems can best be divided up into sections for attention as a unit.

After the men have been selected to handle the different work, the cards must be gone over carefully with the men to decide how often each machine or piece of equipment needs routine attention. This is a matter of experience and can be changed from time to time as needed. The frequence of inspection should be noted on the card. When an inspection is made it should be noted and the card put forward in the pocket for the next date due. If the expense seems warranted the date of each inspection may be entered on the main record card.

Some equipment in constant use under heavy loads may warrant inspection every month, other parts like heating systems if overhauled well in the summer should be expected to operate without major difficulties through the winter although if the system is old this cannot be done. The job of the inspector is to spot ahead of time the work that must be done soon so that it may be properly scheduled and done when most convenient, that is, while the machine is idle such as after working hours or in a slack period.

Inspection Form

To insure a thorough job and remove the personal element as much as possible an inspection form is desirable and this should be made out so that the inspector need only check off the items to look for. In a large plant several forms may be desirable but in the smaller plants one or two will be sufficient.

In many plants repair and maintenance work is done only upon requisition of the head of the department. In one plant this matter is taken care of automatically with a minimum of paper work as follows: The inspector makes out his report in duplicate by means of a sheet of carbon. In addition to checking the regular data, recommended work is noted briefly in space left for that purpose. The form has the department, machine number and name. The original is given to the head of that department by the inspector. At the end of his day's work, the inspector notes on the equipment card the date of inspection and briefly whether or not repair work was needed. He then fills in the heading on a new inspection sheet and drops the new sheet in the tickler file under the next inspection data, a method which eliminates the duplicate file mentioned earlier. The carbon copy of the report is then

turned in to the plant superintendent. The work may be ordered by the head of the department or it may not—that responsibility is not the inspector's and when he tries to assume it, friction usually results and the inspector should be changed.

The inspector's job should be finished with the report and with the copy of the report he turns all responsibility over to the department head and superintendent. If repair work would be inconvenient at the time the master mechanic may be called in to verify the inspector's report or to give an opinion as to whether the work can be put off safely to some future date.

In an inspection and maintenance program the cooperation and good will of the superintendent is necessary and, as is the case always where a large number of departments are involved, diplomacy is a big help in making it a success. Most important, however, is a plan of organized and systematic inspection. The plan itself, the division of equipment, the forms and the paper work involved should best be started in a modest way and developed as experience dictates to meet best the need of an individual plant and the personnel involved.

Thinkers and Doers in Maintenance Work

Statements made in the following article are based on an interview with Frederic Oakhill, Plant Engineer of the United Wall Paper Factories, Inc., Chicago, for many years, until recently, with Bauer & Black and consultant in plant engineering.

FIRST AND foremost in the solution of plant maintenance is the building up of a plant organization that will work in harmony with the management. Human characteristics and aptitudes differ so widely that careful selection of men for specific duties is of prime importance, the problem becoming more complex as the size of the organization increases with possibilities of obtaining greater efficiency in the various phases of the work.

Fundamentally there are two types of men needed in an operating organization—thinkers and doers. Most people are prone to class the thinker or planner as a lazy man, since he is always scheming to accomplish his objective with the least amount of physical work. Such men, however, are necessary in any plant organization, not only in saving their own time in doing the necessary physical work but also in devising ways of saving other men's work and time.

Those in the doers class are men who are commonly spoken of as energetic, they want to get things done, and in a hurry. The trial-and-error method appeals to them as preferable to the method of planning and working projects out on paper as far as possible before materials are purchased, workmen assembled and work actually started.

No one man can be classed wholly in either division but there is in every man a predominating trait that needs to be satisfied if he is to be happy and efficient in his work.

In maintenance work more doers are needed than thinkers since planning can usually be done more rapidly than the physical work can be accomplished and once the plans are put down on paper and found to be practical they become matters of routine that need but slight revision to fit specific cases. In many cases as time goes on and men accumulate experience, those in the doers class naturally slow up physically and develop into thinkers and planners. In every organization these traits of human nature should receive consideration.

Plant Department Organization

This to a considerable extent is the theory back of the plant department organization chart which I have drawn up and used in the management of departmental organizations ranging in numbers from 3 to 100. It really is unlimited in application of the principles involved since in the small plant the duties are combined under a few men and spread among a greater number of more specialized men in larger organizations.

Much may be said in explanation of the details of operation of this chart, but since your interest at this time is in maintenance, we will skip the other features of plant management and confine our remarks to the actual procedure in keeping a plant in an up-to-date and serviceable condition.

Plant operation and maintenance must go hand-in-hand. In most cases the operator must also be the maintenance and repair man. When this is not the case he is required to report defective conditions he observes to his immediate superior, whose duty it is to investigate them and order necessary corrections, and immediately the need for written instructions is apparent.

Records of Operation

Operating records, though essential to safe and efficient operation, are an annoyance to the men who keep the wheels going around and for this reason, if for no other, they should be kept to the essential minimum. In every instance we confine our paper work required of operators to that which will save shoe leather and physical labor. Safety, of course, comes first in our observation of conditions, then economy. Red tape is cut to the bone. Head work and planning precede every job unless it has become a matter of routine. It may be economical to slightly underman the regular staff under present labor conditions than to have men regularly employed who are not kept continuously occupied at work they can do efficiently. Overtime work and pay is appreciated by most workmen, if not excessive, therefore this is one way to handle a back-log of work or an emergency. Sometimes an increase in the crews is desirable. Outside help can be brought in for special jobs to relieve the regular staff when necessary. This arrangement may not work so well in small towns and villages when located at con-

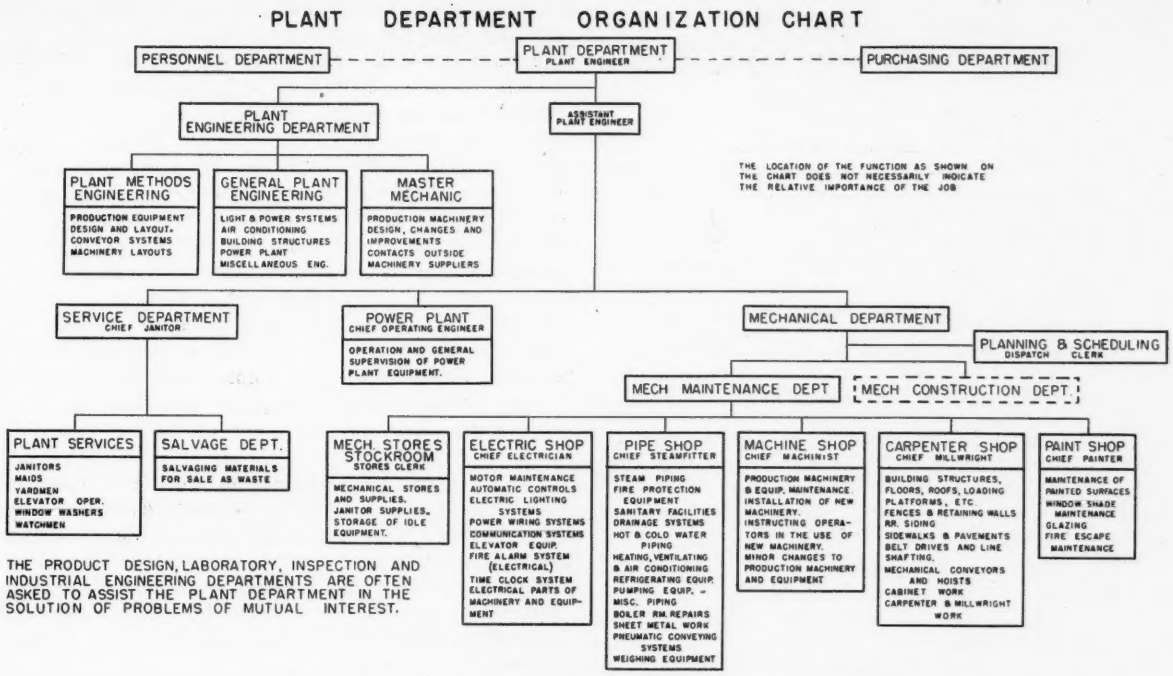

PLANT DEPARTMENT ORGANIZATION CHART
PERSONNEL DEPARTMENT
PLANT DEPARTMENT
PLANT ENGINEER
PURCHASING DEPARTMENT
PLANT ENGINEERING DEPARTMENT
ASSISTANT PLANT ENGINEER
THE LOCATION OF THE FUNCTION AS SHOWN ON THE CHART DOES NOT NECESSARILY INDICATE THE RELATIVE IMPORTANCE OF THE JOB
PLANT METHODS ENGINEERING
PRODUCTION EQUIPMENT DESIGN AND LAYOUT. CONVEYOR SYSTEMS MACHINERY LAYOUTS
GENERAL PLANT ENGINEERING
LIGHT & POWER SYSTEMS AIR CONDITIONING BUILDING STRUCTURES POWER PLANT MISCELLANEOUS ENG.
MASTER MECHANIC
PRODUCTION MACHINERY DESIGN, CHANGES AND IMPROVEMENTS CONTACTS OUTSIDE MACHINERY SUPPLIERS
SERVICE DEPARTMENT
CHIEF JANITOR
POWER PLANT
CHIEF OPERATING ENGINEER
OPERATION AND GENERAL SUPERVISION OF POWER PLANT EQUIPMENT.
MECHANICAL DEPARTMENT
PLANNING & SCHEDULING
DISPATCH CLERK
MECH MAINTENANCE DEPT
MECH CONSTRUCTION DEPT.
PLANT SERVICES
JANITORS MAIDS YARDMEN ELEVATOR OPER. WINDOW WASHERS WATCHMEN
SALVAGE DEPT.
SALVAGING MATERIALS FOR SALE AS WASTE
MECH. STORES STOCKROOM
STORES CLERK
MECHANICAL STORES AND SUPPLIES. JANITOR SUPPLIES. STORAGE OF IDLE EQUIPMENT.
ELECTRIC SHOP
CHIEF ELECTRICIAN
MOTOR MAINTENANCE AUTOMATIC CONTROLS ELECTRIC LIGHTING SYSTEMS POWER WIRING SYSTEMS COMMUNICATION SYSTEMS ELEVATOR EQUIP. FIRE ALARM SYSTEM (ELECTRICAL) TIME CLOCK SYSTEM ELECTRICAL PARTS OF MACHINERY AND EQUIPMENT
PIPE SHOP
CHIEF STEAMFITTER
STEAM PIPING FIRE PROTECTION EQUIPMENT SANITARY FACILITIES DRAINAGE SYSTEMS HOT & COLD WATER PIPING HEATING, VENTILATING & AIR CONDITIONING REFRIGERATING EQUIP. PUMPING EQUIP. - MISC. PIPING BOILER RM. REPAIRS SHEET METAL WORK PNEUMATIC CONVEYING SYSTEMS WEIGHING EQUIPMENT
MACHINE SHOP
CHIEF MACHINIST
PRODUCTION MACHINERY & EQUIP. MAINTENANCE. INSTALLATION OF NEW MACHINERY. INSTRUCTING OPERATORS IN THE USE OF NEW MACHINERY. MINOR CHANGES TO PRODUCTION MACHINERY AND EQUIPMENT
CARPENTER SHOP
CHIEF MILLWRIGHT
BUILDING STRUCTURES, FLOORS, ROOFS, LOADING PLATFORMS, ETC. FENCES & RETAINING WALLS RR. SIDING SIDEWALKS & PAVEMENTS BELT DRIVES AND LINE SHAFTING. MECHANICAL CONVEYORS AND HOISTS CABINET WORK CARPENTER & MILLWRIGHT WORK
PAINT SHOP
CHIEF PAINTER
MAINTENANCE OF PAINTED SURFACES WINDOW SHADE MAINTENANCE GLAZING FIRE ESCAPE MAINTENANCE
THE PRODUCT DESIGN, LABORATORY, INSPECTION AND INDUSTRIAL ENGINEERING DEPARTMENTS ARE OFTEN ASKED TO ASSIST THE PLANT DEPARTMENT IN THE SOLUTION OF PROBLEMS OF MUTUAL INTEREST.

Fig. 1. Organization Chart adaptable to any size industrial plant with but slight modification

siderable distances from cities where specialized tradesmen are quickly available, but consideration should be given to this possible means of handling unusual demands on the crews. Keeping men on hand, assigning them to manufactured jobs, whose main service is to do emergency work is tantamount to admitting your inability to keep the plant in continuous serviceable condition. With proper maintenance and operation, interruptions in service do not generally occur, equipment is repaired before it has a chance to break.

This sounds like theory, it is, but it is a theory that can be made to work except in rare instances outside the control of the plant engineer. Earthquakes, tornadoes, floods, and some fires may bring about conditions which no operating force could prevent, but a well trained staff can detect weaknesses in equipment and overloaded conditions well in advance of an accidental breakdown. After these conditions are reported by the inspector it is the duty of the Maintenance Department to put the equipment in first class working order.

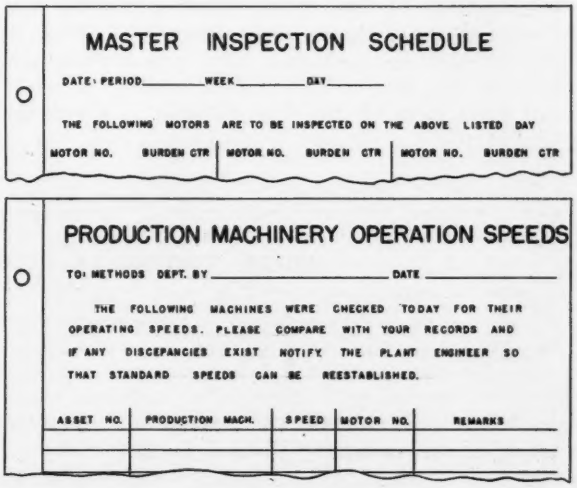
Approach to Maintenance Problem

A good method of approaching any problem is to lay out what might be termed an ideal plan, based upon one's present knowledge of the situation. Naturally, as one's experience broadens, his previously conceived ideal plan will change. The purpose of this ideal plan is to aid in the development of any changes or improvements which might affect the over-all scheme. Therefore, as each step in the development of the ideal plan is undertaken one is in a position to determine how it will affect what has been done and its influence on what might be done. It is very wise to develop the so-called ideal plan even though the ultimate goal may never be attained.

Each major piece of equipment is given a record card upon which is noted data pertaining to replacements and additions, a history of its operating service and repairs, and reports on its condition at times of inspection.

Members of the operating staff are required to report any and every condition they suspect of leading to weakness or inefficiency in operation. Such conditions may also be observed at periods of regular inspection which are scheduled to fit the conditions in the plant. These routine inspections must not interfere with regular plant operations.

If these inspections point to an unhealthy condition, arrangements must be made to give the equipment a more thorough inspection to determine what repairs are required, particular attention being given to parts



MASTER INSPECTION SCHEDULE

DATE: PERIOD_____WEEK_____DAY_____

THE FOLLOWING MOTORS ARE TO BE INSPECTED ON THE ABOVE LISTED DAY

MOTOR NO.	BURDEN CTR	MOTOR NO.	BURDEN CTR	MOTOR NO.	BURDEN CTR

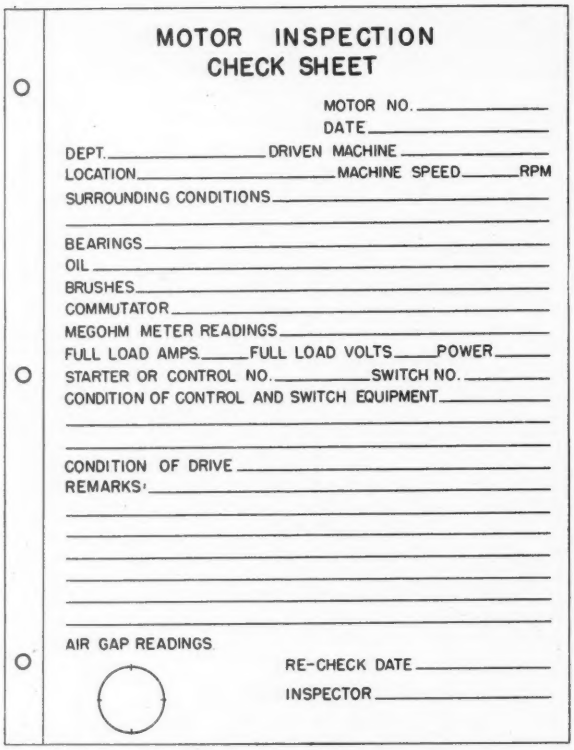
PRODUCTION MACHINERY OPERATION SPEEDS

TO: METHODS DEPT. BY_____ DATE_____

THE FOLLOWING MACHINES WERE CHECKED TODAY FOR THEIR OPERATING SPEEDS. PLEASE COMPARE WITH YOUR RECORDS AND IF ANY DISCREPANCIES EXIST NOTIFY THE PLANT ENGINEER SO THAT STANDARD SPEEDS CAN BE REESTABLISHED.

ASSET NO.	PRODUCTION MACH.	SPEED	MOTOR NO.	REMARKS

Fig. 2. Typical inspection blanks



MOTOR INSPECTION
CHECK SHEET

MOTOR NO. _____
DATE _____
DEPT. _____ DRIVEN MACHINE _____
LOCATION _____ MACHINE SPEED _____ RPM
SURROUNDING CONDITIONS _____
BEARINGS _____
OIL _____
BRUSHES _____
COMMUTATOR _____
MEGOHM METER READINGS _____
FULL LOAD AMPS. _____ FULL LOAD VOLTS _____ POWER _____
STARTER OR CONTROL NO. _____ SWITCH NO. _____
CONDITION OF CONTROL AND SWITCH EQUIPMENT _____
CONDITION OF DRIVE _____
REMARKS: _____
AIR GAP READINGS
RE-CHECK DATE _____
INSPECTOR _____

Fig. 3. Inspection blank for motors

subjected to wear, subjected to strains, and corrosion.

When repairs or replacements of parts are necessary, the ideal plans are referred to, and latest designs of the equipment are studied with the idea that conditions may offer an opportunity to bring the equipment more nearly up-to-date by the use of better material or an improved part.

Periodical Overhaul

Complete overhauling of machine units is done periodically, the frequency depending upon the type of equipment and the service it performs. This work must be done when it will not interfere with production such as on week ends, holidays, factory shutdown periods or slack seasons when the load can be carried on other equipment. The power plant gives 100 per cent service when it answers every scheduled call upon it, a failure or curtailment is a reflection against the maintenance department.

When routine inspection indicates the necessity of shutting down the equipment, complete plans for doing the work are made well in advance of the scheduled dates. Work on important or special units may be done by outside experts, if so, the contractor will be frequently consulted in planning for necessary parts, tools, supplies, instruments, and the like, so that once the job is started it can be completed with dispatch.

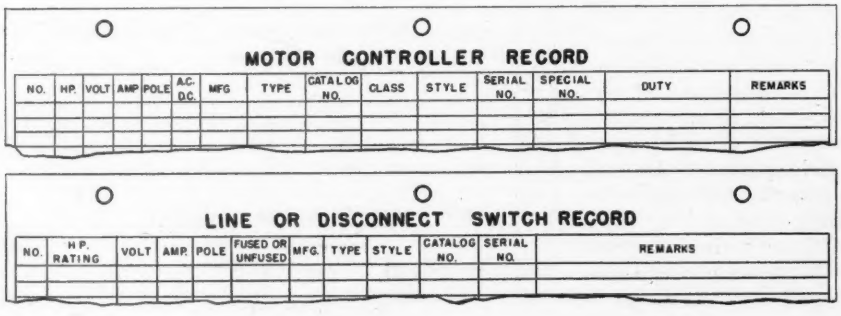
A complete overhaul job means practically rebuilding the machine. When this is done all parts of the machine are removed, inspected and calipered for wear, erosion, corrosion and cracks and only perfect parts are replaced. Electrical equipment windings are inspected and insulation tested for grounds and shorts, contact surfaces such as slip rings, commutator segments, controller buttons, switch blades, are put into condition or are replaced, and the cause of pitting is investigated.

Since much of our overhaul work on large and special units, such as engines, turbines, generators, motors, boilers, stokers and the like, is done on contract, a guarantee of correct performance is required before the work is accepted and a member of our own staff is on hand at all times to be of assistance and observe the condition of parts replaced.

Maintenance for Economy

Maintenance work is not all done to insure safety by any means. Economy is also essential and this may be realized in the elimination of leaks, waste heat, overheated bearings, smoking chimneys, slipping belts. However, many wasteful conditions are discovered only by means of instruments and review of recorded data. Such was the case recently when calculations and investigation indicated that replacing hand fired furnaces with stoker firing would result in economies that will pay for the improvement in about 15 months. Knowing facts and using them usually leads one to an improved situation.

Another really important function of maintenance work when practical is to so schedule the activities that the workmen will be doing work under favorable conditions, all of which is reflected in better and more efficient production as well as better labor relations. An example would be the testing of light intensities through the factory, with a light meter, at regular intervals and making lamp replacements when the light is below standard. Much of this work may be seasonal or dependent upon weather conditions. We usually do our interior painting in winter, exterior



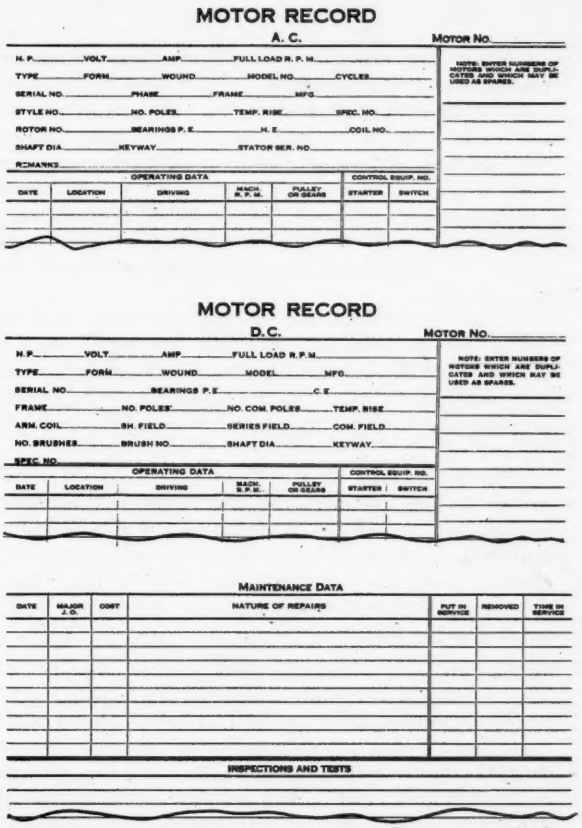
MOTOR CONTROLLER RECORD

NO.	HP.	VOLT	AMP	POLE	A.C. D.C.	MFG	TYPE	CATALOG NO.	CLASS	STYLE	SERIAL NO.	SPECIAL NO.	DUTY	REMARKS

LINE OR DISCONNECT SWITCH RECORD

NO.	H.P. RATING	VOLT	AMP.	POLE	FUSED OR UNFUSED	MFG.	TYPE	STYLE	CATALOG NO.	SERIAL NO.	REMARKS

Fig. 4. Record blanks for small equipment



MOTOR RECORD

A. C. Motor No.

H. P. ____ VOLT ____ AMP. ____ FULL LOAD R. P. M. ____

TYPE ____ FORM ____ WOUND ____ MODEL NO. ____ CYCLES ____

SERIAL NO. ____ PHASE ____ FRAME ____ MFG. ____

STYLE NO. ____ NO. POLES ____ TEMP. RISE ____ SPEC. NO. ____

ROTOR NO. ____ BEARINGS P. E. ____ H. E. ____ COIL NO. ____

SHAFT DIA. ____ KEYWAY ____ STATOR SER. NO. ____

REMARKS ____

NOTE: ENTER NUMBERS OF MOTORS WHICH ARE DUPLICATES AND WHICH MAY BE USED AS SPARES.

OPERATING DATA					CONTROL EQUIP. NO.	
DATE	LOCATION	DRIVING	MACH. R. P. M.	PULLEY OR GEARS	STARTER	SWITCH

MOTOR RECORD

D. C. Motor No.

H. P. ____ VOLT ____ AMP. ____ FULL LOAD R. P. M. ____

TYPE ____ FORM ____ WOUND ____ MODEL ____ MFG. ____

SERIAL NO. ____ BEARINGS P. E. ____ C. E. ____

FRAME ____ NO. POLES ____ NO. COM. POLES ____ TEMP. RISE ____

ARM. COIL ____ SH. FIELD ____ SERIES FIELD ____ COM. FIELD ____

NO. BRUSHES ____ BRUSH NO. ____ SHAFT DIA. ____ KEYWAY ____

SPEC. NO. ____

NOTE: ENTER NUMBERS OF MOTORS WHICH ARE DUPLICATES AND WHICH MAY BE USED AS SPARES.

OPERATING DATA					CONTROL EQUIP. NO.	
DATE	LOCATION	DRIVING	MACH. R. P. M.	PULLEY OR GEARS	STARTER	SWITCH

MAINTENANCE DATA

DATE	MAJOR J. O.	COST	NATURE OF REPAIRS	PUT IN SERVICE	REMOVED	TIME IN SERVICE

INSPECTIONS AND TESTS

Fig. 5. Motor record cards, 5 by 8 in., have identical reading on the back

painting when weather permits during summer and fall. Tuck pointing is usually a spring or fall job. Outside water tanks are best repaired and painted in the summer, as are all jobs on space heating equipment and exterior work of all kinds. Roofs are looked after in spring and fall, while we prefer to do sidewalk calking in the spring time. Air conditioning equipment is worked at its peak in summer, so maintenance work upon its fans, motors, filters and air washing devices is done in winter.

Cleanliness is a cardinal requirement in the operation of power plant equipment, for defects are too easily hidden by a coating of oil soaked dirt and dust. The clean plant is usually the safe plant for the cleaning must be done frequently, and in the cleaning work the operator's attention is called to nearly every kind of defect from cracked or broken parts to steam, water and oil leaks, and even defective electrical insulation. Preventive maintenance allows the correction of minor faults before they become serious shut-downs.

Thus it will be seen that maintenance work is initiated by the operators, is carried on by inspectors who determine the danger point, taken up by the planners who make all arrangements for maintenance and repairs, carried through by tradesmen, passes again through the inspectors' hands and is turned over to the operators in first class condition. Therefore, it is desirable to have the thinkers and doers work hand-in-hand for the safety and economic advantage of all associated with the business.

Summer Repairs— Not a Problem

Repair work can be scheduled to avoid the summer rush, to regularize employment, and to keep building service facilities at high efficiency. By Lyman R. Flook, Superintendent of Buildings and Grounds, University of Chicago.

THE USUAL rush of summer extra work on mechanical equipment at the University of Chicago has been spread fairly well over the twelve months of the year. This has been done by planning and scheduling. By means of monthly log reports each foreman who supervises the operating and maintenance men reports in summary form the unusual items of repair accomplished during the month, the progress on jobs remaining unfinished at the end of the period, and has opportunity to list jobs needed, with special outline reports, of work requiring attention.

By inspection, surveys, and complaints, the parts of the plant not functioning at best efficiency, or operating for a scheduled period, or reaching a state of unprofitable operation, through obsolescence or hard service are studied, and a recommendation for action is initiated, usually by the foreman, frequently by the office, sometimes by another department. A preliminary study outlines the need, and with a preliminary estimate, *always* makes a justification, based upon necessity, or upon the investment return. To each such report Mr. Carty's* three tests are applied: (1) why do this at all? (2) why do it now? and (3) why do it this particular way?; and those who make such reports usually provide the answers to these three very important questions in their proposals!

By means of such studies and numerous inspections, the maintenance policy may be controlled, and a record of breakdowns in service can be turned into one of smooth functioning efficiency. Not the least of the advantages of the scheduling of special repairs or replacement of machinery or parts is the very desirable one of regularizing employment to the end that the men can get twelve month's pay every year.

The great group of buildings which house the work of the University of Chicago are very much more than a school since varied activities of many groups include housing and feeding, large hospital units, libraries, laboratories, a manufacturing press, and a variety of affiliated activities,—although even the school activity operates four quarters a year, or a vacation period in September, usually less than one month.

As a result, the mechanical equipment of the buildings has been planned for adequate capacity. The power house has one spare boiler in periods of heaviest loads, sewage ejector pits are provided with twin pumps, and so on, with the usual reliance on Sunday or holiday work for an emergency repair job.

*Formerly Chief Engineer, A. T. & T. Co.

Although major emergency repairs can be very largely eliminated by frequent inspection by qualified men, the replacements and testing, repair and adjusting required to offset wear and usage is of large proportions.

To meet these needs a few of the regular practices might be of interest.

Steam Meters

Semi-monthly reading of steam meter equipment indicates minor repairs or adjustments needed from time to time. Every two years each meter is removed from the line and taken to the meter-testing laboratory in the Blackstone Avenue Power Plant, where it is opened, cleaned, repaired, and carefully calibrated, and reinstalled. This year 60 shunt-type and 8 displacement-type meters were so checked. Repair costs for material were less than $3.00 per meter. The labor was performed by the regular meter maintenance man with only a little help from other mechanics.

Heating

The care of steam heating systems in buildings is scheduled, traps are inspected once a year, by opening them up. Recent experience indicates that for vacuum radiator traps about sixty per cent of the traps must be removed every three years, for new elements, seat repair, or replacement. Thermostat radiator valves require new diaphragms, every three years for rubber, every four years for metal bellows, although the recently improved rubber diaphragms will doubtless give longer service.

Scale pockets at the base of vertical piping require opening at least every three years.

Ventilation

Fan rooms usually house large heating and tempering coils which require little care beyond cleaning and occasional painting, and complete repair of pipe covering, an occasional repair or replacement of canvas joints, and careful adjustments of dampers.

Dry-cell, or unit air filters are a source of much expense, the cells are removed, steam-cleaned, dipped in fresh oil, drained, and replaced four times each year. For more recent buildings, the blanket type air cleaner reduces this large cost. Fan bearings are cleaned and lubricant replaced. Air velocities are checked and the dampers of main ducts are adjusted.

Air Piping

The many small compressors for thermostatic air require frequent inspection, and every six or seven years an overhaul is desirable—tanks, filters and pressure reducing valves are checked, and defective parts replaced.

Swimming Pools

The mechanical filtration of water requires large pump and filter capacities. Filters are opened once each year, and the sand level restored, with complete replacement of sand about every five years. Chemical and sterilizing equipment is cleaned, and rusted surfaces painted.

Code Painting

After pipe covering is repaired and casings and piping is painted, the service is indicated by a colored arrow 8 in. long, with a ½ in. bar, using a stencil, the arrow pointing in the direction of flow. These arrows are placed in obvious and easily-read locations, preferably in good light, and are most highly recommended. The colors now used are: Steam h. p., bright red; steam l. p., brown; return, brown; waste and vent, black; water, cold, light blue; water, hot, dark blue; air, yellow; gas, black.

It has been found that the machine rooms and fan rooms look best with solid colors for pipe covering, casings, motors, and metal parts, usually a light warm gray color, with white walls and ceilings—the colored arrows show up well, and with proper spacing can be decorative.

The annual cleaning and repairing of machine rooms always turns up suggestions for improved economy, convenience, or safety of operation. These ideas are reviewed—and result in changes in piping, changes in control, and almost without fail, the need for more convenient lighting, better gages or measuring equipment and the like.

Special Work

Many special jobs turn up, some of them unexpectedly. A few might be of interest to illustrate the general nature of our repair work.

During the winter, and between runs of experiments, the compressor of the ammonia cooling system for several constant-temperature rooms was overhauled, after 25 yr. in service, a two-cylinder vertical machine. The cast-iron cylinder walls, rings and pistons were badly worn, and the crank shaft was badly scored, lightly at the bearing surfaces, heavily at the packing gland areas. The cylinders were bored out, fitted with a new and larger piston with new rings, the shaft was metallized and turned down to its original dimensions, the bearings were repaired, and the machine made ready to run, at a reasonable cost, and with every prospect of a very long life at reasonable efficiency.

This morning the upper half of the casing of the 7.5-hp. water booster pump (225 g.p.m. at 70 ft. head) was removed. The impeller was filled with small stones, and the shrouds worn by small stones in the casing clearance, and the shaft was worn badly at the rubber and flax packings. A new shaft and impeller of bronze will be ordered, and the pump put in service at the end of the warm season, for nine months operation during the cold season. A larger 20-hp. pump (425 g.p.m. at 104 ft. head) being operated for the four warm months, set in parallel, permits this repair to be made any time during four summer months.

These practices keep step with the work of two committees which function during the heating season, one whose function is to conserve steam, of which 70 per cent is used for heating, and the other to conserve electricity.

Needless to say, the best maintenance is the cheapest—to stop steam leaks, to avoid breaks which reduce service, and to preserve the physical plant by cleanliness, and attention to prevent rust and deterioration.

Maintenance Policy

Each year's cost of operation should bear its proper share of the quick but certain loss through use and service, to the end that each part of the plant shall be in equally good condition at the beginning of the new fiscal year, as it was at the beginning of the last one. Such cost, if not spent, should, in fairness, be charged and held, until such time as replacement or renovation is imperative.

Service by Contract

It is possible, now-a-days, to make contracts for service to maintain important machinery or equipment. Such contracts are very successful and well-known for electric elevators, and for special purposes, such as for window washing, and pipe organs. It is hoped that the future will see the development of such service contracts for many more of the activities of mechanical maintenance, especially for the smaller operator of expensive machinery, as new services prove themselves.

Life of Metal Duct Work in Buildings

Today I examined a 14 in. by 22 in. elbow from the ventilation system installed in a laboratory building in 1897. The metal was No. 24 gage galvanized—not a bit of rust was in evidence—the inside surface was dirty, 1/16 in. on the bottom, much less than on the sides. This good condition, after 42 yr. of use, is more than twice the usual length of useful life recommended in widely-used tables of depreciation, and the elbow examined was, to the best of our knowledge, a fair sample of the other parts of the system in the building, as superficial examination of the other parts of the system showed. The original fan and housing, but with new coils and dampers (1928), and a new motor (1930) by reason of change from d.c. to a.c. are the only changes—a long history of useful life, now estimated to be only half over.

Protective Maintenance

Policies adopted for the operation of equipment in the Chicago plant of the Container Corp. of America, outlined by Robert Krause, Plant Engineer, to the editor of POWER PLANT ENGINEERING

IT IS one thing to be in charge of a power plant where the equipment is all new, or reasonably so, and quite another to be responsible for continuous operation of equipment that has long since become obsolete but not sufficiently expensive to operate that it should be replaced entirely. Minor or even major parts of an engine or stoker may show weakness or give way entirely and if observed and replaced in time, the unit may be kept in service for many years without danger and at comparatively little maintenance cost. To keep on the safe side of maintenance work in a plant that has gone through several equipment generations, expansions and replacements is a distinct art, for only judgment and an uncanny sense of warning can keep such a plant in continuous service.

Plant Equipment

Such is the art displayed by Robert Krause and his staff of operating engineers and maintenance men at the paper board factory of the Container Corp. of America, located on the north bank of the river in down town Chicago. From what has been said, it should not be inferred that all reasonable precautions are not taken to indicate approaching failures or that the equipment is "held together with bailing wire" for neither is the case. Much of the equipment is old, however, and extreme, watchful care is needed to keep it operating safely and economically.

Maintenance work is continuously going on in this plant, most of it being performed by the regular factory crew but when extensive replacements, repairs requiring specialized skill or installation of large important equipment is done, outside services are frequently contracted for. To comprehend the maintenance problem here an idea of the character of the plant and its size is necessary.

In all essentials, this is a paper mill plant making cardboard from pulp and waste paper. Its location between the north bank of the Chicago River and the barge slip gives unlimited water supply for condensing, process, and boiler feed purposes and permits delivery of coal by barge or rail. A bucket conveying system with a capacity of 275 t. per day carries the coal from a track hopper to the boiler room bunker.

Steam is generated in boilers of the water tube type, two 500-hp. B. & W., two 400-hp. Lasker-Adams and six 300-hp. Stirling, all set on one side of the firing aisle in batteries of two with a solid partition wall. The usual load carried runs around 165,000 lb. per hr. of steam at 160 lb. pressure, no superheat. Chain grates serve all of these boilers; some employing only natural, others forced draft, automatic combustion control being provided for only two of the boilers.

Electric current is generated by two turbine units, one of 1500 and the other of 500 kw. capacity. The 1500 kw. unit is of the extraction type delivering bled steam at 25 lb. pressure for process heating, and exhausts to a jet condenser. The 500-kw. unit exhausts to a surface condenser, vacuum carried in both cases averages 26 to 27 in. This arrangement results in a feedwater make-up of about 50 per cent, the raw water from the lake being treated in a hot lime-soda system.

Throughout the factory a number of steam engines are installed to drive equipment either by direct connection, through belts or ropes. Under normal operating conditions the turbine units furnish all the electric power required by the factory but connection is made for utility service only when the factory is down.

Very little space heating is required except in the offices; what little factory heating is required is supplied by unit heaters. These and radiators in offices are supplied with exhaust steam from engines and auxiliary drives.

Record System

Maintenance work logically starts with an adequate though not elaborate record system. Years of experience has enabled the staff to eliminate a large share of the clerical work which was at one time thought advisable. For instance, in the power plant

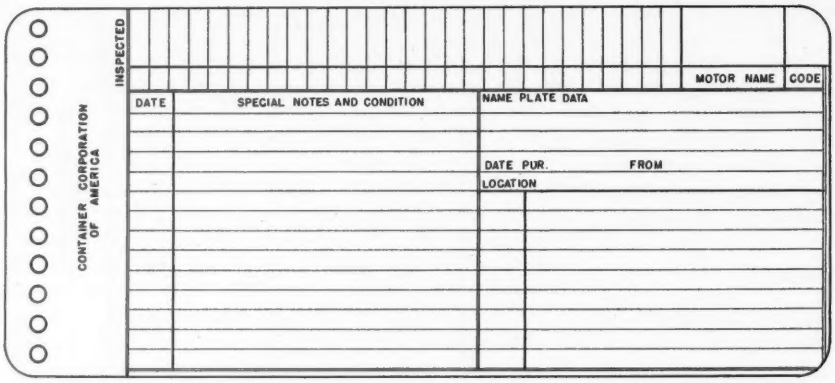


Fig. 1. Form used for recording data on motors

and factory are hundreds of electric motors ranging in capacity from fractional up to several hundred horsepower. An attempt was made at one time to keep a ledger account of each one of these, the work involved, however, became extremely burdensome so the policy was gradually revised until now such a record is kept but with particular attention only of motors over 25 hp. A loose-leaf form used for this purpose is shown in Fig. 1. Smaller motors are so often shifted from one service to another and so easily replaceable that the present policy is to keep a supply of spare motors on hand and in first class condition so that changes can be made quickly whenever the need arises. The service record kept of these is not as complete and accurate.

In the operation of this entire plant it is the duty of all workmen to report to their immediate superiors any and all unusual conditions observed in line with their work. This is relayed to the maintenance inspectors who make an observation of the condition and determine whether or not an immediate shut-down seems necessary. If not, special operating attention is given the equipment until detailed inspection and repairs can be made without interrupting scheduled operation. All maintenance work is ordered by the head of the department whose equipment is affected. A maintenance requisition blank similar to that shown in Fig. 2 is generally used for this purpose.

Another type of inspection regularly employed is that of systematic routine. Periodically the different types of equipment are given careful inspection in addition to the observations of operators. This applies to such equipment as mechanical drives including belts, ropes, chains, shafting and accessories; to motors, pumps, stokers, electrical appliances such as controllers and starters. These inspections frequently lead to maintenance jobs, the need for which is not apparent to the routine operator as the inspector is provided with special tools, instruments and other equipment as well as being given an opportunity to examine the equipment while it is out of service.

Maintenance Department

Repairs and replacements of all kinds are done by the maintenance department regularly employed for the factory and power plant. This department maintains a well equipped machine shop fitted with both metal and woodworking tools and has available hand and portable tools and instruments. Included among this equipment are: Machine lathes, drill presses and shapers, with experienced tradesmen to operate them; acetylene and arc welding units; a full complement of pipe bending, cutting and threading tools; bolt threading machine; wood planers; wrenches; machinists' and micrometer calipers; a.c. and d.c. ammeters, voltmeters and wattmeters; levels and dial level gages; engine indicator; portable draft gages and CO_2 analyzer; tube cleaners, tube rollers; portable grinders; air hammers and air compressors; paint spray guns. These are all available for use by the combined staff.

Some Major Jobs

An idea of how this system works may be gained from the history of some of the repair jobs.

One steam engine unit purchased during the war was built on Navy specifications with the crank disk of cast iron. At one of the overhaul periods an incipient crack was noted. The scheduled shutdown time was not sufficient to make a permanent repair so the part was measured up and the engine put back in service while a new steel crank disk was made in the machine shop. At the first opportunity the replacement was made without loss of production time.

Some years ago one of the steam engines evidently got a dose of water with the result that a cylinder head was blown off. Repairs were made to the cylinder and valves and the engine has been running ever since but during a recent inspection the piston was found to be cracked. This unit is now scheduled for a complete overhaul job.

MAINTENANCE REQUISITION

DATE ISSUED_____ DATE WANTED_____

DESCRIPTION OF WORK_____

REASON FOR WORK_____

REQUESTED BY_____ APPROVED BY_____

Fig. 2. Requisition blank used by maintenance department

An important boiler rehabilitation job is now under way in this plant affecting the six Stirling boilers that were completely overhauled 10 yr. ago. These boilers were installed in settings of two placed side by side with supporting steel columns encased in a solid refractory wall which separated the furnaces. Periodic inspection by the operating staff and insurance inspectors has indicated a gradual buckling of the center supporting columns due, no doubt, to the high temperature to which the columns are subjected. While the danger point has not been reached in any of these settings, the rehabilitation work has been started and will continue, one setting at a time, until all boilers are in first class condition.

This work will consist in a complete overhaul of the boilers, including replacement of defective tubes, repair of injuries to drums, addition of a front water wall, rebuilding of the center supporting structure and providing for air circulation in the partition wall, the monolithic baffles will be replaced with tile and, in the furnace side walls, arches will be built to make possible replacements in the lower section without the necessity of disturbing the upper part of the wall. Similarly the chain grate stokers will be thoroughly overhauled with warped bars and burned links replaced.

These changes are being made in order that the furnace temperatures will be reduced, thus relieving the temperature strains on the partition wall. The water wall will also add considerable capacity to the present installation. These changes should also reduce the cost of maintenance on the furnace refractory and stoker.

In all this maintenance work the object is to catch defects before they have spread to major proportions and thus avoid excessive repair expenses and surprise failures that interfere with production. Every day

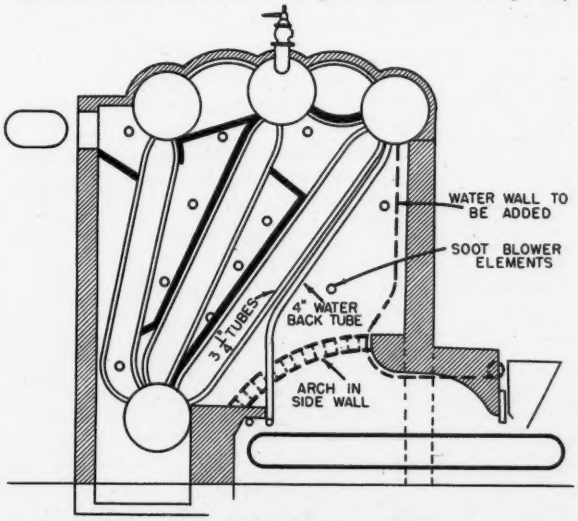


Fig. 3. Cross section of boiler indicating changes to be made

the operating staff is continuously busy tightening bolts, adjusting packing glands, mending belt seems, replacing gaskets, reconditioning bearings, adjusting lubrication—a thousand and one detail duties any one of which may seem trivial but if properly performed and while in the insipient stage, may forestall a major repair or replacement job.

Care of Insulating Oils

By S. H. COLEMAN

DANGER of insulating oils becoming contaminated in storage or while being transferred can be minimized by closely observing the following precautions:

1. Whenever a container of oil has been received from a transportation company or has been moved, inspect its closing device, to be sure it has not become loosened by handling or temperature variations.

2. Protect drums of insulating oil stored outdoors from direct rain and snow and see that they are placed on blocks to prevent their resting on wet ground or other damp surfaces. Never allow a drum to be stood on end but lay it on its side with the bungs turned downward at an angle so that no water can stand around the opening, nor the plug be the point of drippage.

3. When a container of cold oil must be taken into a warm room, it will sweat, and if opened immediately it is probable that moisture contamination will occur. To prevent this the container should be allowed to reach the temperature of the room air before the closure is loosened. This may require as much as 8 or 10 hr., depending upon the initial difference in temperature and the volume and shape of the container.

4. To prevent condensation of moisture from the air when equipment is filled the oil should preferably have the same temperature as that of the apparatus. In no case should the oil temperature be below, and never more than 10 deg. C. (18 deg. F.) above, the receptacle into which it is poured.

5. Preparation for the filling of apparatus, both outdoor and indoor, should be done under the best possible atmospheric conditions and where this is impractical every precaution should be taken to prevent moisture pollution.

6. Vessels used in transferring the oil must be thoroughly dry and dust free. Cotton waste or fuzzy rags should not be used to wipe out these receptacles as some lint will be unavoidably left behind to contaminate the oil, and since cotton lint carbonizes readily, will adversely affect its dielectric properties.

7. When transferring oil from containers in which it has been stored, remember that scale may have become loosened from the metal during handling. This possibility should be guarded against by centrifuging or filtering the oil before placing it in the equipment. Where this is impractical the oil should be strained through at least two thicknesses of heavy closely woven cloth that has been thoroughly washed and dried to remove the sizing. Frequent changes of cloths are also recommended.

8. Empty drums that have contained other oils should never be refilled with insulating oil if it can be avoided. When it must be done the drums should be thoroughly cleaned, all traces of the original contents removed, and the foregoing precautions strictly adhered to in order to prevent contamination. Even though the empty drums formerly were filled with insulating oil these safeguards must also be closely observed.

Great Thoughts On Power

By H. E. M. KENSIT

THE GIFT of expressing material but desirable things in eloquent and appealing language gives inspiration and encouragement to those who may be laboring under difficulties. The following extracts have been noted over a good many years from a mass of United States, British and Canadian technical journals and it appears that of those given hereunder the most truly eloquent are of American origin. That the Americans are an eloquent people is frequently in evidence and not least so by their inscriptions over public buildings, as for instance the moving sentences on the general post office in Washington, D. C. The first and earliest of the quotations below is, perhaps, the most far-seeing and that by Dr. Pupin of Columbia University perhaps the most eloquent:

"The belief is a growing one that electricity, in one or more of its manifestations, is ordained to effect the mightiest of revolutions in human affairs."

Thomas Ewbank. U. S. Commissioner of Patents. 1849.

* * *

"No changes have ever equalled those through which the world is passing now. The manufacture of power has an intellectual as well as a physical effect, it has separated power from the mind which must manage it."

Julian C. Smith. Shawinigan Water & Power Co. 1918.

* * *

"—whoever controls a nation's power controls that nation's people."

Henry Ford, in Kansas City Times, March 18, 1922.

* * *

"—the moving power of heat and the moving power of electricity are eternal—they are also the only propelling powers in the evolution of the luminous stars. Radiations from these stars tell us that the moving powers of heat and of electricity are of celestial origin; they were brought to earth on the wings of solar radiation and remained dormant until the genius of Watt, Carnot, Oersted, Faraday and Henry called them to the service of man."

Dr. I. Pupin. Columbia University. 1932.

* * *

"Every day of every year 300 cubic miles of water is raised from the oceans and dropped on the earth—to carry on that continuous drama of rearranging everything that has life and things that have not life."

General Electric Review. September, 1930.

(*Note.* And not least, to endlessly renew by the cycle of evaporation and rain, our non-depletable and inexhaustible waterpower.)

* * *

"Civilized man differs from uncivilized man in the amount of power which he uses."

Frank D. Adams. Dean of the Faculty of Applied Science, McGill University.

* * *

"The nations of the world rank in wealth and prosperity in the ratio of the number of times through mechanical power they have multiplied their man-power."

P. S. Arkwright, President, Georgia Power Co. 1930.

* * *

"To gather the streams from waste and to draw from them energy, labor without brains, and to save mankind from toil that it can be spared, is to supply what, next to intellect, is the very foundation of all our achievements and all our welfare."

Justice Holmes. U. S. Supreme Court.

* * *

"Electricity is the most faithful farm-hand that the world has ever seen. It brings a life of ease to the farmer."

R. J. Ambler. "Electrical Canada." September, 1930.

* * *

"A town is only as big as its power resources."

Sault Ste. Marie Star. October 29, 1930.

* * *

"We owe the present American standard of living mainly to our use of greater quantities of power per inhabitant than any other people on earth."

Governor Pinchot of Pennsylvania in "Giant Power" report. 1925.

* * *

"New possibilities for the furthering of human comfort and well being confront us on all sides and for the realization of all these there is a growing demand for *power* and still *more power.*"

Otto M. Rau. Consulting Engineer.

* * *

"This 50 years concludes the real development period of what we now call electrical engineering. ———At that time there were no electrical engineers. Extraordinary men originating in the shop, like Swinburne, met great scientists like Sir William Thomson, as we knew him then, to break new roads on which civilization would travel."

William McClellan. Past President A.I.E.E. 1934.

* * *

"From the beginning of history, the growth or degree of civilization of a race or nation can be determined by———the utilization of the sources of power."

F. L. Morse, The Morse Chain Co. 1923.

* * *

"This is one of man's greatest victories over nature. It is as if our country suddenly had a new State added to it, for a new and wider use of this controlled water will care for millions of people and create billions of wealth."

Dr. Wilbur, Secretary of State, in address at the initiation of the Boulder Dam.

The PRACTICAL ENGINEER

DEVOTED TO PLANT OPERATION and MAINTENANCE

A. W. KRAMER, EDITOR

WE WERE PLEASED

We were quite pleased with the way in which the first issue of the Practical Engineer was received. During the month we have had a number of comments come in on it, all of which were favorable and some containing suggestions which we shall try to incorporate in future issues.

As we implied in the preliminary announcement in the June issue, we shall probably have to experiment a little to find out what type of material and what method of treatment appeals to most of the readers. One thing seems quite certain and that is that the "Question and Answer" section will continue to be published in every issue. There seems to be a definite interest on the part of many operators in questions and answers, and we shall endeavor to make this department as alive and vigorous as we possibly can. As pointed out, elsewhere, the first reaction to the "How Would You Do It?" prize problem contest was not as strong as we should like to have had it but a number of readers have sent in solutions and we hope that interest in this feature will grow. We feel that the problem being presented this month offers more opportunity for discussion than did the one last month and we look for an increased degree of interest.

We want to emphasize again the importance on your part in making the "Practical Engineer" interesting and valuable. Do not hesitate to send us your ideas. As an operator of a plant your knowledge and experience can be made of value to others, and you, yourself, will benefit in presenting it.

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A Section of Power Plant Engineering

TECHNICAL PUBLISHING COMPANY
53 WEST JACKSON BLVD., CHICAGO, ILL.

A short discussion of a remarkable engineer and his work. Dan Gutleben, Plant Engineer of the Pennsylvania Sugar Co. and dean of sugar house engineers in this country, to our mind is more suited to his work by both training and temperament than anybody we know. Technically trained, he is also the most intensely practical engineer in the game today.

A MAN AND HIS WORK

LAST MONTH in introducing this new section of POWER PLANT ENGINEERING we discoursed briefly upon the horrors of "impractical" engineering. As may have been suspected that article was written to a certain extent because it was necessary to have an "introduction" and we chose that subject because it involved incidents within the writer's own experience. We might, however, have chosen some other subject which would have served equally well as an introduction.

Now, however, that we have had a month in which to think about it we feel that the somewhat negative method of emphasizing the need for practical engineering by a discussion of impractical engineering is an effective one. The horrible example method of approach can, of course, be carried to extremes but as we pointed out last mouth, no engineer who has had to suffer for the impractical sins of others will make the same mistakes himself. We learn by making and observing mistakes.

We Visit Pennsylvania Sugar

During the month we had the delightful privilege of visiting once again our old friend Dan Gutleben, engineer par excellence and dean of sugar house engineers in this country. Mr. Gutleben is the plant engineer of the Pennsylvania Sugar Co. and his name is almost a byword in the neighborhood of Shackamaxon Avenue and the Delaware River in Philadelphia, for Dan is human as well as practical. We know of no man more suited to his work by training and temperament than Dan Gutleben. Year in and year out Dan Gutleben keeps the great refinery in Philadelphia running smoothly and efficiently; during his spare moments he designs new plants and refineries for the company. Now he also has a dry ice plant. CO_2 is a by-product of the alcohol plant; countless billions of minute bacteria convert the molasses into alcohol and in the process liberate CO_2. This is compressed and expanded and finally pressed into cubes of dry ice by great hydraulic presses. When they first developed the process, they had difficulty in sliding the blocks of dry ice from the smooth steel bed of the press; the dry ice tended to stick to the steel and the corners of the blocks were often torn off. Various methods were tried to overcome the trouble—the beds of the presses were even chromium plated. This helped somewhat but it was not entirely satisfactory and the plating soon wore off.

An operator, one day, suggested putting a sheet of paper on the bed of the press before the solid CO_2 was formed and when this was done, the block with the paper attached was easily slid off the press. Now a stack of paper lies beside the press and before each block of dry ice is formed a sheet of this paper is laid on the press. This, is "practical" engineering. Simple? Yes, but it took the operator to discover it.

Sometimes we think that some of the sweetness of the product which is so much a part of Dan Gutleben's life has become absorbed in his disposition. From the neighborhood school kids whom he shows through the plant to the distinguished foreign visitors who come to his plant every year, he shows the same regard and courtesy. Once in a while some equipment manufacturer will make a request for a bag of raw sugar; maybe he wants to try out a new style of filter. Subscribing to the good neighbor policy, they send him the bag. After a while they may receive an elaborate report commending the remodeling of the plant—all based on intensive research suffered by that poor orphaned bag of sugar—one of millions coming from all sections of the tropics. Well, as Dan says, this does no harm and it may do some good.

Where Bacteria Make Alcohol

Visitors came to this plant last year from Java, Japan, Phillipine Islands, Hawaii, Australia, England, Germany and the neighborhood school. The boys from Australia and England are great travelers. They charge the cost to research. They are willing to accept the experiences of others,—wherein they differ from the young fellow who insists on sowing his own wild oats. Among the visitors was the "Direcktor" of a German sugar house who found it more helpful to remain in America. The school kids got in by a fluke. One murky morning a barge of mixed coals, heavily water laden, caused the boiler operators some difficulty. At this stage a message came in requesting the Chief Engineer to call up the Principal of a neighborhood school. First he sent a warning to the boiler

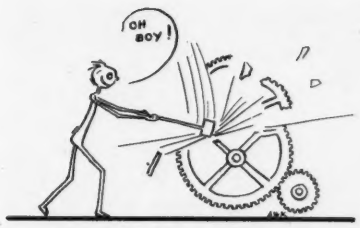
house to curb the smoke and then under some misgivings, he took on the call from the Principal. She requested permission to bring her "opportunity class" (i. e., the little rascals) for a visit to the refinery. Besides the two teachers we had three guides and a police sergeant to pilot the boys through the works. At the end of the trip their pockets were bulging out with samples of sugars sequestered from various stages of the process.

Sometimes the superintendent of the plant wants to know, for instance, how much load can the gear wheel on the crystallizers take. Mathematical analysis isn't satisfactory, so Gutleben orders him to break it and find out. This information costs $100. This also, is practical engineering. In the end it is probably more satisfactory than having a high powered theorist spend the same amount of money in arriving at a theoretical answer which may be wrong.

Other times, purely analytical methods work better. Upon one occasion it was necessary to rebuild the moving element of a spiral conveyor. The old tinsmith at the plant is an expert and there are few things he cannot tackle, and he could have laid this spiral out by means of his practical graphic methods. But Dan Gutleben realized that this might take him several days so he took the problem to his office and worked out a solution analytically. This took two hours.

Occasionally a piece of apparatus refuses to behave according to expectations. Sometimes goes wrong. The wiseheimers convene to consider the mystery. When the cogitations do not yield a ready answer, the problem becomes obstinate and a heroic remedy is sought. The prescription becomes involved in proportion to the depth of the mystery! Finally the complicated diagnoses are refined, a simple remedy develops and the cloud is dispersed. It takes time to be brief.

An outstanding example is the secret of the tube failures during the preliminary operation of the new boilers. For two years the plant suffered some thousands of dollars' loss and many headaches. Then by an inspiration a little baffle was installed in the No. 2 boiler drum at a cost of $250 and presto the baffling enigma is solved.



We Tell Him to Break It

Sometimes they make mistakes at the Pennsylvania Sugar plant; they try to keep the number down but they accept them when they come and endeavor to profit by them. "Everybody makes mistakes," says Dan Gutleben, and thereby adds to his stock of valuable experience.

Since progress is made by stumbling over mistakes, the Log records first-time errors in judgment as a lesson against recurrence. The Accounting Department, who used to receive copies, placed an arithmetical interpretation upon the errors and became so perturbed that they dictated letters about them. They could not apply the proper interpretation to the records and so they had to be removed from the mailing list.

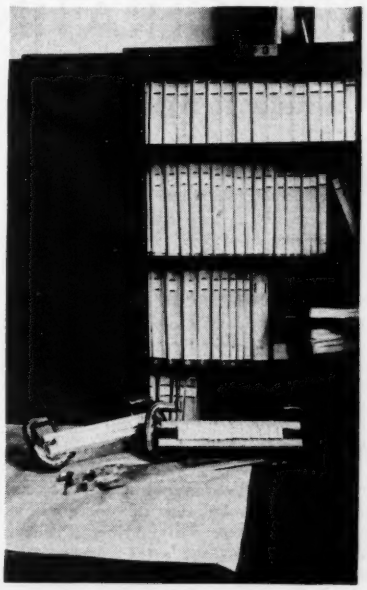
The "truths" do not require gilding but they should be conveyed in language that makes them sound like truths. They must be attractive to receive the Boss' acceptance and appropriation.

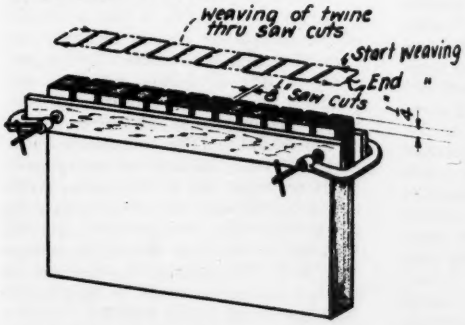
We could fill up these entire 16 pages of the Practical Engineer with incidents from Dan Gutleben's log but we will keep some for later issues. Before we conclude, however, we want to present his philosophy of the plant engineers' work as contained in his own modest account of his daily activities.

A plant engineer must be a specialist at generalization. He is expected to be able to design his plant and build it. When obsolescence threatens he must keep the plant in competitive condition. His first requirement to success is to ally himself to a skillful and energetic manager. He is usually late for Sunday dinner because of an interesting job at the works and his holidays are of the bus-man's variety which he spends in visiting other plants.

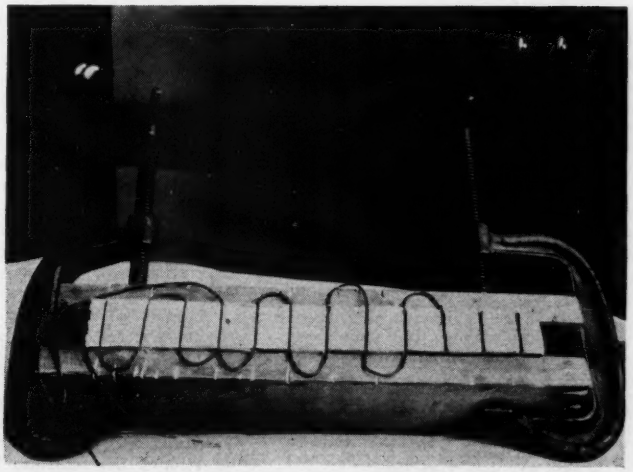
One thing more, and this involves a practical contribution to the "Practical Engineer." It has to do with Mr. Gutleben's system of binding technical magazines. Back files of technical magazines he says (and we agree) are essential to the reference library of every engineer, and are useful provided they are bound. Since these books are not used long or vigorously (nor viciously) a home-made binding is satisfactory. The method illustrated here has proved simple and satisfactory. Some of Mr. Gutleben's volumes date back to 1920.

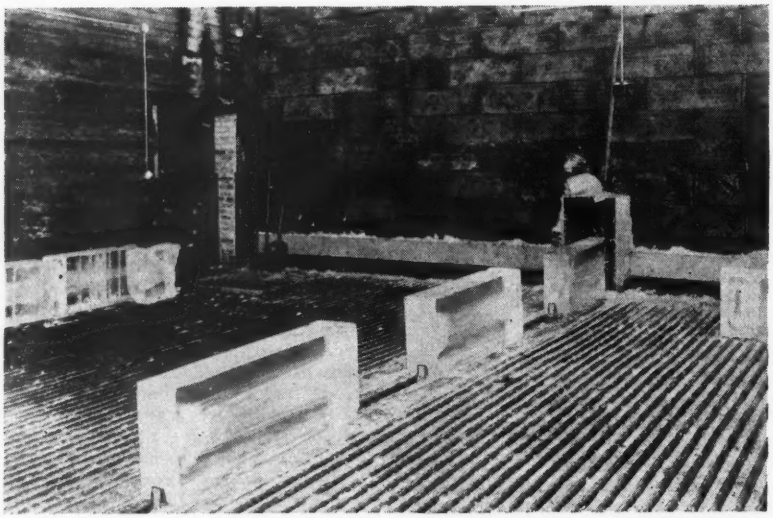
The first time this economical device came to his attention was in 1900 when it was used by Fred Buffum (M. I. T. 1900) while he was a draftsman in the structural department of the Cambria Steel Co. That was the period when draftsmen sought versatility through frequent shifts and considered it a sin to remain in the same job more than three months.





1st Clamp magazines as shown and sandpaper back smooth
2nd Make saw cuts about 1/8" deep and 1" apart
3rd Weave twine thru saw cuts
4th Paint back with Le Pages Glue





REFRIGERATING PRACTICE

Corrosion in Brine Systems

CORROSION in brine systems is common but may be eliminated by carefully following the recommendations* made by the A. S. R. E. Corrosion Committee a few years ago after an extensive research program.

For calcium chloride brine, the corrosion tendency can be corrected by adding approximately 100 lb. of sodium dichromate to every 1000 cu. ft. of brine. This is about 1.6 grams per liter. In addition sufficient sodium hydroxide should be added to convert the dichromate to a neutral chromate. For neutral brines this is approximately 27 lb. sodium hydroxide for 100 lb. of dichromate. Where ammonia has been absorbed by the brine, however, the amount of sodium hydroxide required will be less. Where the brine shows red after phenolphthalein is added to the sample taken after the dichromate has been added no sodium hydroxide is needed.

The retarder can be dissolved in warm water and the solution poured slowly into the circulating brine. A more convenient method, however, requiring less labor and assuring better distribution is to hang the dichromate in a bag at a point where rapid brine circulation will dissolve it. In order to have the retarder maintain its effectiveness, it is advantageous to analyze the brine each year. However, approximately one-half of the original amount of dichromate added once a year is usually sufficient to prevent further corrosion difficulties.

For calcium magnesium chloride and sodium chloride brines the same procedure is recommended except that 200 lb. of dichromate should be added for each 1000 cu. ft. of brine. The same procedure of adding alkali and renewing the dichromate annually is necessary.

In sodium brines disodium phosphate can be used as an alternative method. It should be used in approximately 100 lb. per 1000 cu. ft. of brine and this amount should be added each month. The brine must be kept neutral or only slightly acid by the addition of muriatic acid if necessary.

Phenolphthalein can be used to test the brine and if a pink color is observed the acid should be added until the color disappears. The retarder must be dissolved in hot water and added slowly to the brine at a point in front of the agitator. This retarder is not as effective as dichromate but it has the advantage of being non-irritating and non-poisonous to the skin of workmen.

In addition to the chemical retarder, it is advisable to keep air away from the brine as much as possible. The elimination of dissolved oxygen will largely prevent corrosion difficulties. It is also advisable to hang test pieces of galvanized iron, bare iron or steel in the brine system to observe the corrosion and the effectiveness of the corrosion preventive treatment.

When the brine is not treated it should be maintained slightly alkaline at a pH value of about 8.5. If phenolphthalein is used as an indicator, a faint pink coloration should be maintained by the addition of a small amount of caustic soda or milk of lime.

Contact of dissimilar metals should be avoided and strict cleanliness should be observed about the plant. When paint is to be applied to a corrosion system, the surface should be cleaned thoroughly. This consists not only of the removal of scale and dust but in some cases heating to remove the moisture film. A good inhibitive priming coat followed by a waterproofing coat properly applied will often give good protection. Exposed threads in galvanized pipe lines can be protected by means of a lacquer containing flake aluminum or aluminum bronze.

*A summary of this Corrosion Committee Report and research is summarized in Circular No. 10 which may be obtained for $1.00 from the American Society of Refrigerating Engineers, 37 West 39th St., New York City.

Cracked Ice

WHEN PULLING ICE it is good practice to have a number of extra cans on hand so that those just pulled can be allowed to temper before dipping and dumping. If the ice is too cold it will crack and can be entirely ruined by dipping into even comparatively cool water. Sometimes a few cans in some part of the tank will crack consistently. Generally it will be found that this kind of trouble is due to cold brine and upon close investigation circulation will be found to be the direct cause.

In one plant of this kind cracking was so bad in one end of the tank that the cakes always shattered when they were dumped. Circulation was diverted by means of a wooden partition and the trouble stopped entirely. It is well to note freezing time in different parts of the tank and change the circulation so as to have freezing uniform in all parts. Thermometers in different parts of the tank help in maintaining uniform temperature.

After dumping the ice out, the cans should remain on the rack long enough to drain thoroughly. Failure to do this often results in discolored ends from dirty water left in the can. To make good clear ice requires careful attention to comparatively small, unimportant details.

After dumping, blocks of ice should not be allowed to bump against each other for if this bumping does not smash the whole block, it will knock off the corners. Walls in direct line with the ice chute should be protected with bumpers made from old hose or automobile tires.

Advantages of CO_2 as a Refrigerant

WHILE CO_2 is not as common a refrigerant as ammonia, it has a number of advantages in certain locations for it is odorless and harmless. This is particularly true in hotels, hospitals, department stores, and food storages, etc., where ammonia leaks may be dangerous or objectionable. The compressor cylinders are small because operating pressures are high due to the characteristic of the refrigerant. In an ammonia plant the back pressure ranges from 15 to 25 lb., and on the high side from 150 to 175. In a CO_2 machine the pressure on the low side is about 300 lb. and on the high side from 900 to 1000 lb.

While carbon dioxide requires smaller compression cylinders, has no odor and is less dangerous to life and costs less per pound than ammonia, the latter has some advantages. First the pressures dealt with are much lower making easier

to prevent leaks. Also the leaks are more easily detected because of the smell and the ease of detection with a sulphur candle. A small leak in a CO_2 system is much more serious due to the higher pressures and the extra loss soon offsets the difference in cost on a pound basis.

Again the critical temperature of ammonia is about 88 deg. F. Allowing a 10 deg. F. difference between the latter and the refrigerant, limits the condenser water temperature to about 78 deg. F. The critical temperature of ammonia is 271 deg. F. and much warmer water can be used.

Non-condensible Gases in Refrigerating Systems

AIR AND OTHER NON-CONDENSIBLE GASES tend to collect in certain parts of the refrigerating system, particularly in the condenser and liquid receiver. While these gases may be inert and play no part themselves, they do interfere with operation for two reasons: First, they tend to blanket certain parts of the heat transfer apparatus and reduce the capacity; and second, due to the partial pressure which they exert, they increase the head pressure and consequently the power consumption of the compressor.

As a rule they will be carried along with the refrigerant and gradually collect at the coldest part of the condenser. When a section of the condenser becomes cold, it should be shut off from the ammonia header and water circulated over it 2 to 5 hr. and the section then purged. The small valve or petcock provided for this purpose should be opened slightly, preferably with the end of the discharge piping submerged in a pail of water.

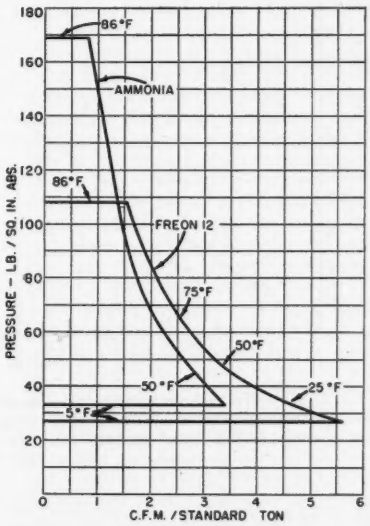
Non-condensible gases as they are driven out will bubble through the water without being absorbed but when the ammonia starts to flow through there will be a crackling sound somewhat like steam when turned into cold water. As soon as the ammonia starts to flow the cocks should be closed. After a few minutes the process should be repeated. Usually the flow of non-condensible gases will stop after a few purgings.

Some of the gas will often be carried with the ammonia to the bottom of the condenser and into the receiver. The receiver can be purged by taking a ½ in. connection from the high point of the receiver up to a small section of double pipe condenser. A purge connection as described above should then be taken from the highest part of the condenser. The ammonia piping should be pitched so that the ammonia which condenses in the purge condenser will drain back to the receiver. Purging from the receiver may be done periodically or continuously. If the valve is kept cracked such an arrangement can be often kept in operation continuously but regardless of this the end of the purge pipe should always be kept under water so as to absorb any ammonia that escapes.

The Standard Ton for Refrigeration

FOR PURPOSES of comparison the standard ton of refrigeration is taken as 288,000 B.t.u. per 24 hr., with an evaporator temperature of 5 deg. F., a compressor inlet of 14 deg. F., condenser temperature of 86 deg. F. and liquid temperature 77 deg. F. The pressure in the various parts of the system will depend upon the refrigerant used. For a number of refrigerants these pressures, in pounds per square inch are: in the evaporator, Freon 26.5, ammonia 34.3, sulphur dioxide 11.8, methyl chloride 20.89; in the condenser, Freon 107.9, ammonia 169.2, sulphur dioxide 66.45, methyl chloride 95.53.

Freon is intermediate between ammonia and sulphur dioxide as far as pressures are concerned and for standard ton conditions the pressures are always



Pressure volume indicator card for Freon and ammonia shown for standard ton conditions

above atmosphere. For a standard ton operation, a Freon machine will displace 5.56 cu. ft. of vapor per min. as compared with 3.4 for ammonia, 9 for sulphur dioxide and 5.8 for methyl chloride. Freon systems, therefore, require larger liquid lines and expansion valves than ammonia. The flow of liquid for a standard ton is: for Freon 0.045 cu. ft. per min.; 0.011 for ammonia, 0.016 for sulphur dioxide and 0.022 for methyl chloride. The accompanying drawing shows an ideal indicator card for Freon and ammonia under standard ton conditions with the adiabatic temperatures along the compression line indicated. The area of the Freon cycle is 0.959 hp. and that of the ammonia cycle is 0.979 hp.

Refrigerating Condensers

ONE OF THE MOST important parts of a refrigeration system from the standpoint of power consumption is the condenser. If this is not sufficiently large and in good operating condition, the head or discharge pressure increases. This causes increased compressor power which in severe cases may be sufficiently great to overload the motor and cause serious trouble.

Clean surfaces mean that scale and sludge must be removed periodically from the tube surfaces and the design of the condenser itself and the plant where it is located should be such that this cleaning can be done easily. With some types of cooling water the tubes without regular cleaning may be coated with scale so badly that the heat transmission may be reduced as much as 50 per cent in two or three months.

Frequency of cleaning must be determined by the engineer and will depend upon the scale forming properties of the water, and the temperature rise. The surfaces should be kept clear by scraping or by the use of wire brushing followed by washing with clear water. The cost of the cleaning must be balanced against the increased power consumption of the compressor.

In addition to having clean heat transfer surfaces, the design must be such that the water distribution over the tubes and surfaces is even and the velocity reasonably high, natural circulation is so slow that artificial circulation by means of a pump is necessary.

In the usual atmospheric condenser it is essential that water fall in drops or in fine streams over the top of the tubes and be evenly distributed along the length. In double pipe and horizontal shell and tube condensers, the water circulation is positive provided there is sufficient water to fill the tubes.

Heat transfer and consequently the capacity of the condenser will increase with the water velocity. Increased velocity means higher friction losses and increased water quantity so that cost of the water and the power required in pumping must be balanced against the effective capacity and consequently cost of the condenser.

Rugged Rod or Wire Shear

By Chas. H. Willey

MANY a good pair of snips have been dulled or nicked by trying to shear steel rod or wire with them. The sketch shows how any handy mechanic can convert a couple of old wornout files into a heavy duty wire or rod shear.

The tool consists of two parts, the plain moving blade and the notched one. The latter is made by heating one file, upsetting, and flattening fan shape, then grinding the notches or filing them in before rehardening. The notches of course are different widths.

FOR THE DIESEL OPERATOR

Engine Starting Air

INTERNAL COMBUSTION ENGINES are usually started by compressed air and this compressed air is commonly stored at a pressure of around 250 lb. in air receivers or tanks. The capacity of these tanks required for a given installation will depend upon the size and the number of engines, the starts normally required in a day, the number of the receivers and size of the air compressor.

The size or dimensions of the receivers have not been standardized, but a tank 20 in. in internal diameter and 60 in. long with a cubic content of 11 cu. ft. is a popular size. Such a tank weighs from 450 to 500 lb. when made for 250 lb. working pressure, is easy to handle and install and in case larger capacity is required a number of tanks may be used in multiple. The end and side elevation of such a battery is shown by Fig. 1.

Time required to pump up the tank from atmospheric pressure to a given pressure can be calculated approximately from the formula—

$$T = \frac{V\ P}{10\ D}$$

In this formula T is equal to the time in minutes; V is equal to the receiver volume in cubic feet; P is equal to the final tank pressure in pounds per square inch gage; and D is equal to the compressor displacement of the low pressure stage in cubic feet per minute. The relationship holds true up to about 500 lb. pressure.

This formula can be solved by means of the chart, Fig. 2. In a given plant the volume of the tank or receiver and the displacement of the compressor are constant and usually it will be possible to locate the point A of Fig. 2 so that to solve for the time required to pump from atmospheric to a given pressure, it is only necessary to draw a straight line from the desired pressure P through A to the time in minutes on the T scale.

Inasmuch as the time is given in minutes required to pump the receiver from atmospheric to the final pressure, the chart may be used for determining the time required to pump from one pressure to another by subtracting two quantities, for instance if the pressure has dropped to 200 lb. and it is necessary or desirable to pump it back to the 250 lb., first determine the time required to pump 200 lb., then determine the time required to pump to 250 lb. and subtract the two. The result will be the time required to pump the tank from 200 to 250 lb.

Air starting compressors are usually installed in duplicate, one motor driven and one gasoline engine driven unit. The motor driven compressor is handier to use for maintaining the pressure while the gasoline engine driven one is necessary to provide starting air in case no electric power is available.

In some plants where there are a number of units, some of them operating at all times, only one compressor is installed but provision should always be made to drive this compressor either with a motor or a gasoline engine. With belt drive it is easy to switch from one drive to the other. This arrangement saves a few dollars in the cost of a compressor but is generally considered rather questionable economy as accident to the compressor at a critical time would leave the plant without starting air in spite of the fact that dual drive was provided. Starting compressors are usually of the two stage type although three and four stage are sometimes used in large plants.

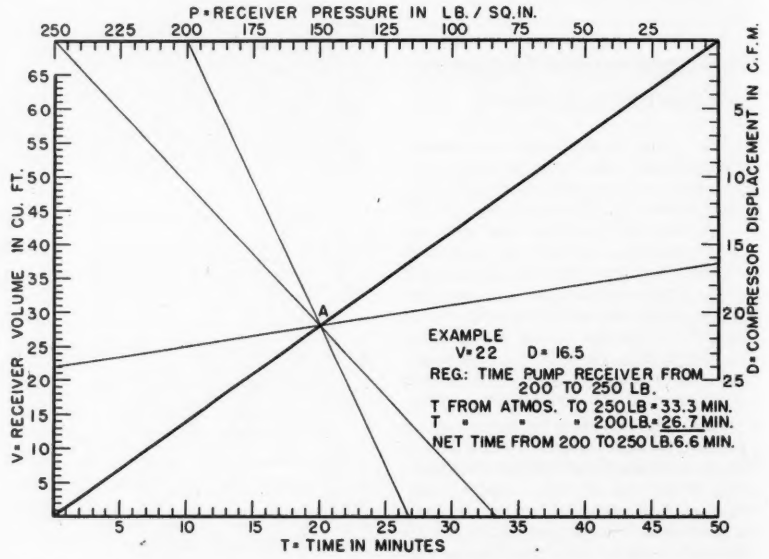

P = RECEIVER PRESSURE IN LB. / SQ.IN.
250 225 200 175 150 125 100 75 50 25
V = RECEIVER VOLUME IN CU. FT.
65 60 55 50 45 40 35 30 25 20 15 10 5
D = COMPRESSOR DISPLACEMENT IN C.F.M.
5 10 15 20 25
A
EXAMPLE
V = 22 D = 16.5
REQ: TIME PUMP RECEIVER FROM 200 TO 250 LB.
T FROM ATMOS. TO 250 LB = 33.3 MIN.
T " " " 200 LB = 26.7 MIN.
NET TIME FROM 200 TO 250 LB. 6.6 MIN.
5 10 15 20 25 30 35 40 45 50
T = TIME IN MINUTES

Fig. 2. Chart for determining the time required to fill air tanks for a given size compressor. In case the receiver is already partially charged, substract the time required to bring the receiver up to this initial pressure from the time required to bring the receiver up to the final pressure

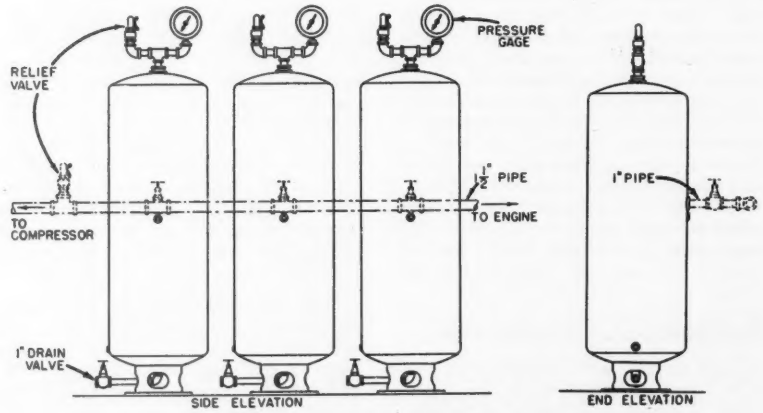


Fig. 1. Typical arrangement of air receivers for starting air

Diesel Cooling Water

WHEN DIESEL first conceived the engine which bears his name, he thought that it could be operated satisfactorily without water jacketing the cylinders. Experimentation, however, showed that water jackets were necessary and they are incorporated on all working Diesels. The exact amount of water required, or rather the heat removed by the cooling water, depends upon the engine design and whether or not the exhaust manifolds and pistons are water cooled. The heat dissipated this way ranges from about 1500 to 3500 B.t.u. per brake horsepower hour for Diesel engines and from about 3800 to 6400 for gas engines. The average value probably lies between

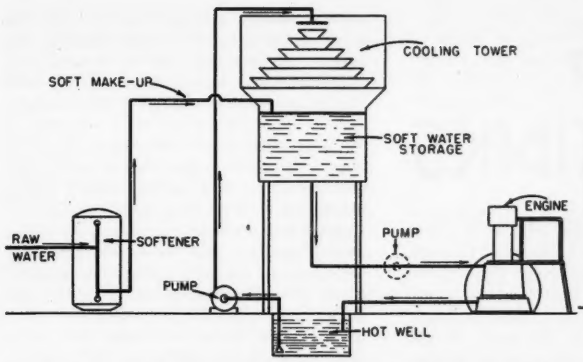


Fig. 1. Diagrammatic arrangement of an open cooling water system with a cooling tower and soft water storage on the roof. If the cooling tower and water sump cannot be elevated a soft water circulating pump, as indicated by the dotted line, is necessary

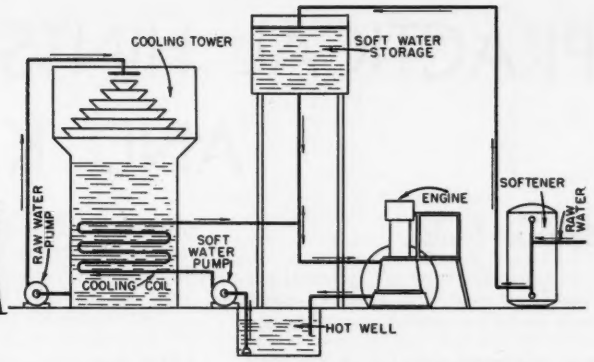


Fig. 2. Diagrammatic arrangement of a typical closed system for engine cooling water. A closed system is slightly more expensive than the open system but the soft make-up requirements are materially reduced and the engine given positive protection against scale

2500 and 3000 for Diesels and 4000 to 5000 for gas engines.

Cooling water temperature rise should be kept low, from 15 to 25 deg. F., for best results in order to get good circulation through the water jackets and also to reduce thermal stresses and prevent scale formation.

When large quantities of soft water are available at a low pumping cost, the water may be run through the engine, preferably from an overhead supply tank which maintains a constant head or level on the jacket. This used to be common practice in the early days and can still be used advantageously especially in industrial plants where the warm water can later be used in the process. It is, however, usually too expensive where the water must be purchased or pumped from a considerable depth.

Another disadvantage is that in few parts of the country is a soft water supply available. It is, therefore, necessary to make provision for reclaiming the water. This can be done easiest in the so-called open system of cooling water shown by Fig. 1. Considering average engine performance and water temperature rise, from ¼ to ⅓ g.p.m. circulation is required for each brake horsepower. The heat picked up in the water, ranging from 2500 to 3000 B.t.u. must be dissipated to the cooling tower where it is lost by evaporation. Each pound of water evaporated requires approximately 1000 B.t.u. So roughly some 2½ to 3 lb. of water must be evaporated each hour for each brake horsepower hour developed. This is approximately 2 per cent of the water circulated.

Due to the evaporation which leaves the impurities in the water behind, the concentration of the water in a system of this kind increases rapidly even though the original water supply is quite soft. This can be improved to a certain extent by using only soft water makeup and commercially this is usually done by the Zeolite softener because of its simplicity.

Small spray ponds are sometimes located on the roof although in larger installations it is necessary to locate it on the ground or to use a spray pond. If the cooling pond and water sump or storage are below the level of the engine it is necessary to provide a soft water circulating pump as shown dotted in Fig. 1.

Evaporation loss in the cooling tower is not the only water loss, in fact it may be a minor one. Under average wind conditions, a spray pond loses from three to five per cent from windage, an atmospheric tower from one to one and a half, and a mechanical draft cooling tower with a proper eliminator system may reduce this loss one-fifth to one-half.

Soft make-up can be cut from a half to a third by using a closed system. At the same time the engine is given more positive protection because only soft water comes in contact with the engine parts and the water in this part of the system is not evaporated but is cooled by cooling coils usually in the base of the cooling tower. The arrangement of a typical closed system is shown by Fig. 2. Even when a circulating pump is used to supply the water to the engine, it is necessary or at least advisable to have an elevated tank floating on the system. This provides a constant head at the engine and in case of pump failure provides an emergency source of supply for the engine operation.

In some sections of the country flat roofs are used and drains arranged so that rain water caught on the roof is stored in a cistern and kept for make-up in the soft water system. Even when such facilities are provided, however, it is usual to install a small softener so that in case rain water gives out some means will be available for supplying soft water make-up without danger of contaminated soft water system.

Grout Gun Simplifies Resetting

By M. T. Pate

EXCESSIVE VIBRATION of a battery of high speed Diesels was traced to erosion of the top surface of the grout on the foundations. Regrouting was ordered rather than attempting to draw down on foundation bolts and possibly set up stresses which would result in fractured bases. When the old grout was chipped out with air chisels it was found that the flow under the bases had been far from satisfactory, even though the puddling when running foundations had been as thorough as usual.

To avoid a repetition of this failure, it was decided to force the grout under the engines with pressure, and a grouting gun was devised to facilitate this work. The gun consisted of a 4 ft. length of 6 in. pipe, reasonably smooth on the interior and fitted with a leather faced ram which sealed the bore in its passage. Heads for the gun were made up of short sections of pipe, all being grooved for separable couplings of the Victaulic type. The upper head carried a valve and connection for an air hose, the base section, an outlet for the grouting hose and a wide base for stability.

Sketch of grout gun: G, pipe barrel for containing grout; C, couplings for attaching heads to gun barrel; R, leather faced ram for forcing grout and preventing aeration or dilution; A, air inlet control valve; O, connection for grout hose

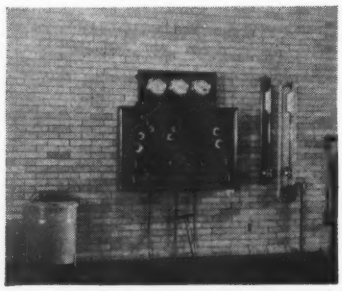
Using this gun, with a short hose and a distributor tip made from a flattened tube (salvaged from a vacuum cleaner) it was possible to pack the grout under an engine thoroughly, and to build up the space between the edging boards firmly with the material. To recharge the gun, once the ram had been forced to the bottom of its travel, both heads were disconnected, and the pressure end clamped where the base had just been. The barrel was then filled from the open end, on top of the ram, and the base again clamped in place. Then, simply by reversing the gun, it was again ready for attaching hoses and resuming placing of the grout.

On the job described the gun was powered with compressed air, as this was available from the starting compressors used with the engines. Had air not been available, however, water under normal main pressure would have been adequate, as the leather facings on the ram prevented either channeling by air or dilution by water.

PRACTICAL HINTS AND KINKS

Special Tools

LARGER MACHINES are ordinarily purchased complete with a set of special tools needed for erection and maintenance work. Unless care is taken to keep these tools segregated they are seldom available when they are needed. To avoid



Special tools

this difficulty it is well to mount them on a board adjacent to the machine. The accompanying photograph shows the arrangement used in the municipal plant at Worthington, Minn., for the new turbo-generator installed a couple of years ago.

Crank Case Oil Level

IT IS IMPORTANT that the oil level in an engine crankcase be kept at a reasonably constant level. In some cases this is difficult because the level cannot be determined accurately because the oil foams. This characteristic is influenced somewhat by the oil itself but is usually the result of a poor installation. Occasionally baffles are arranged so that oil flow to the pump is retarded and the pump suction pipe takes air. This air mixes with the oil and foam results. This trouble can usually be corrected by removing or lowering the baffle, by using a lighter oil or by changing the oil level. In one case the difficulty was corrected by changing the pressure relief connection. The overflow from the relief valve had been discharging directly at the pump suction and carried air bubbles down into the main body of the oil and these were drawn into the suction of the pump.

The Economizer as a Calorimeter

IT IS EXTREMELY DIFFICULT to obtain the weight of two gases passing through the boiler, but where a separate economizer is used the weight of these gases and consequently the flue gas heat loss can be calculated quite easily. It is necessary to measure the water flow through the economizer, temperature rise of the water and temperature drop of the gases.

Various quantities are related because the heat given up by the gases is absorbed in the water, therefore the following fundamental equation can be set up—

$$w\ (t_1 - t_2) = CW\ (T_1 - T_2)$$

In this equation t_1 is the temperature of the water leaving the economizer in degrees F.; t_2 is the temperature of the water entering the economizer in degrees F.; T_1 is the temperature of the gases entering the economizer in degrees F.; T_2 is the temperature of the gases leaving the economizer in degrees F.; w is the weight of water passing through the economizer in pounds per hr; W is the weight of gas passing through the economizer in pounds per hour, and C is the specific heat of the flue gases. This is usually taken as 0.24.

Determining the values is a simple matter and the formula can be transposed so that w can be solved for directly. No chemical analysis of the fuel or gas are required, although if the per cent of heat loss in the flue gas is calculated it is necessary to know the heat value of the coal per pound and the coal burned in pounds per hour.

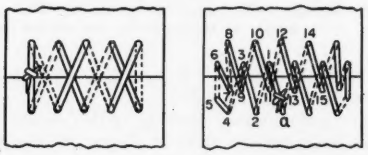
After determining the weight of the gases, the per cent of stack loss can be found as follows: Multiply the total weight of gases in pounds per hour by the specific heat of the gases, by 100, and by the temperature difference between the gases leaving the economizer and the air temperature in the boiler room temperature. Then divide this quantity by the product of the total pounds of fuel burned per hour and multiplied by the heating value per pound.

Belt Lacing for Light and Heavy Duty

ALTHOUGH a number of patented belt lacings and fasteners are available, it is occasionally necessary or desirable to shorten belts or lace them with leather or rawhide thongs. The lacing thongs should be softened and stretched somewhat to render them firm and even. As purchased they vary in width from ¼ to about ¾ of an inch and in thickness from 1/64 to nearly ⅛ of an inch. The holes punched in the belt should be just large enough to admit the lacing thong and should be from ¾ to 1 in. from the end of the belt. The following sizes are generally considered adequate: Small belts, ¼ in.; belts from 4 to 8 in. wide, ⅜ in.; belts from 8 to 15 in. wide, ½ in.; belts over 15 in. in width, ¾ in.

First the end of the belt must be cut square, that is at right angles with the sides of the belt, for if the ends are not square the belt will not lie straight on the pulley and will tend to run off and otherwise interfere with proper operation.

Many methods of lacing belts have been developed and that shown by Fig. 1A is sometimes called the machinist's lacing because it is commonly used among machinists and combines speed with strength, can be easily remembered and makes a satisfactory job on narrow belts and light loads. Beginning at the right hand side of the belt, with the lace stretched through and both ends even, lace with both ends of the thong to the opposite side. The ends may be fastened in a



Two simple methods of lacing belts

square knot or fastened by pulling through two or three holes in the belt.

In heavy driving belts where the strain is severe, double rows of holes should be punched. Here again there are many different methods of lacing used but that shown by Fig. 1B is easy to follow and is one of the best. Begin with one end of the lacing at "a" and lace successively through holes 1, 2, 3, etc., back to the starting point. Some engineers prefer lacing in which the thongs are parallel to the direction of motion for it is felt that this keeps the ends of the belt in the proper position. The lacing shown in Fig. 1B is not parallel but the slant on one side is in one direction and on the other side in the other direction so that the tendency to cross pull is neutralized.

Installing Valves

By P. F. Rogers

IN SPITE of the fact that there are a large variety of valves available there seems to be little uniformity among engineers as to the way the different types are used and installed. For practical purposes they may be divided into two types; globe and gate valves. The so called needle valve which fills a very important place is in effect a variety of globe valve and operates on the same principle.

Gate valves are intended primarily for full open or shut service and should not be used for throttling. When full open they offer little frictional resistance to flow, one of their biggest advantages. When used for throttling service, especially if the valve is nearly closed, the valve and seat is subject to wear. This means leaks when the valve is closed for it is not so easy to renew the valve and seat of this type of valve. If the valve is used with water which has considerable silt or with steam carrying much salts from the boiler they may collect in

the groove between the seats and prevent tight closing.

When installed in a vertical line double disc valves are subject to jamming so that if such a location cannot be avoided a solid wedge type should be used. In as much as a gate valve is used primarily for shut off service they are sometimes difficult to open because of the unbalanced pressure. Therefore large gate valves when used for high pressures should be fitted with a bypass valve so that the pressures on the two sides can be equalized before the main valve is opened. Many types of large valves now available have a bypass valve of this kind incorporated in the main valve.

When the flow must be controlled or throttled a globe valve should be used. Engineers generally consider that a globe valve should be installed so that the flow should be up through the body past the valve, that is so the pressure is under the valve when it is closed. There is no generally accepted or correct method however and it all depends upon the service and location. Where it is necessary that the flow continue in spite of damage to the valve or stem the flow should of course be up past the valve so that it will tend to open.

This is the case for instance in boiler feed and reciprocating pump discharge lines. The reason is two fold. First the discharge from these pumps is pulsating and sometimes set up violent pulsations which when the pressure surges come on top, have a tendency to loosen the valve from the stem. Second, if the valve does loosen from the stem when the pressure is below it, there is no danger of the valve falling in place and stopping the flow. This builds up dangerous pressures and may damage the pump or piping.

Needle valves should be used where the accurate control of small flows is necessary. These valves when made of proper material for the job stand up well under severe service and easily renewed.

Burner Control Valve Change Aids Firemen

By M. T. Pate

SOME OF THE most helpful ideas developed around a power plant are least conspicuous, but when once devised and installed are so obvious that the wonder is why it took so long to make the change. In one power plant as simple a thing as swinging the valve stems on the valves used for regulating gas flow to burners through 90 deg. from the conventional placing cleared the space in front of the boiler setting of what had formerly cluttered the aisle, and at the same time so located the hand wheels as to place the fireman in the best location for observing the fire as he regulated the valve setting.

These same burners were also equipped with the unions in the gas lines in the risers, just above the valves. With this location of the union, one man can change burners easily, resting the weight of the rear end of the burner in its proper place on the riser line as he spins up the union, instead of having to strain to preserve alignment of the union parts as would be the case were the joint in the horizontal line. Interchangeability of burner units is assured through the use of but one make of unions, gasketed, so the male section remains in place on the riser at all times.

Repairing Concrete

By F. Paul

IN INDUSTRIAL PLANTS the repair of concrete floors and walks is often difficult because time is not available to properly dry and cure the concrete before it must be placed back in service. When this is the case the following method can be used and if the work is started after working hours, and the patch allowed to set over night, it will be ready for service in the morning.

The hole or depression should be thoroughly chipped out to solid material and well beyond any oil stains for oil deteriorates concrete badly. The edges should be left rather rough and the chipping done so that there is a good anchorage for the new material. The hole should then be filled with a mixture made of half sharp sand and half cement mixed well and moistened with just sufficient water to give a stiff mix.

This should be well troweled in, packing firmly around the edges and anchors, and then smoothed off well on top with a straightedge and troweled smooth. The entire patch should then be covered with a ½ in. layer of flake calcium chloride. This is a cheap and common chemical used for brine in refrigerating plants and obtainable from any large supply house. This method or repair insures a good bond between the old and new concrete and sets quickly so that it can be trucked over in from 6 to 8 hr.

How to Use Wrenches

A WRENCH is a simple tool yet its very simplicity has resulted in most men believing that its correct handling is an automatic and natural human function. This is not so and the cost of man's ignorance has ranged from barked knuckles to actual loss of life.

In an honest attempt to eliminate accidents, we reproduce a few simple rules from a booklet recently published by J. H. Williams & Co., New York.

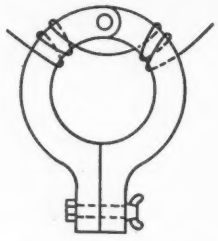
1. Be sure any wrench is fully and squarely seated before pulling.
2. When using a solid (non-adjustable wrench) be sure to select the correct size opening for the nut or bolt accommodated. A partial grip often results in accidents.
3. Do not pack shims between the nut and wrench jaw.
4. Don't expect open-end wrenches to be safe for hard pulls on worn or rounded hex nuts.
5. Do not use open-end wrenches with badly chewed, worn or spread openings —particularly on hex nuts.
6. Think before you *push* on a wrench. In most cases it is safer to pull. Pull straight to avoid side strain or "cramping" of the wrench.
7. Make sure your footing is good, and your hands dry, before you pull.
8. Never attempt to loosen or tighten a nut on moving machinery.
9. Don't interlock the jaws of two open-end wrenches to increase their leverage. You're risking serious injury.
10. The application of hammer blows as a substitute for leverage is bad practice (unless you use a striking-face box wrench).
11. When operating an open-end wrench in close quarters, "flopping" it upside down between swings permits continuous rotation of the nut in the least possible space.
12. Any heating or re-hardening of wrenches should be avoided.
13. For greatest strength in adjustable and monkey wrenches, pull on the side of wrench that carries the fixed jaw.
14. Exercise extreme caution when using any adjustable wrench in a risky pulling position.
15. Never use a wrench as a hammer.
16. Always use a wrench strong enough for the job.

Swinging burner control valve stems ninety degrees from usual location clears passageway at boiler front and aids combustion control. Unions in risers simplify job of changing burner units

Questions And Answers

Current Transformer Ratings

Q. We have a current transformer with hinged laminations, a hole in the center for the primary, and with the secondary coils arranged about as shown in the sketch. The ratio is 250 to 5. As shown, the secondary turns cover only a small portion of the core. Can a transformer of this type be used with as many primary turns as possible passing through the hole? Will the ratio of



transformation be changed in proportion to the ratio of the number of turns?

Worcester, Mass. B. G.

A. In order to circulate five amperes through a given secondary load, a definite number of ample turns is necessary in the primary. If the turns are increased, therefore, the primary amperes are decreased in the same ratio. As many primary turns may be used as the space in the opening permits.

Where Should a Thermostat Be Located?

Q. In installing a thermostat to control the temperature of the air in a room, does it make any difference as to the height above the floor the thermostat is mounted?

Paterson, N. J. J. Gerace

A. Naturally, the thermostat should be located at the height where the temperature is such that it will produce the most comfortable temperature for the occupants in the room. The height is not always as important as the location in the room. If there are air currents in the room, either from the opening of doors or windows or from other openings, these may strike the thermostat and cause it to produce uncomfortable conditions, too warm or too cold. The thermostat should always be located in an atmosphere that conforms to the average of the desired conditions in the room which it controls. The height usually varies between 4 and 7 ft. from the floor. The condition of the air near the wall on which the thermostat is mounted should be investigated. Sometimes there are strong upward or downward drafts along walls and this would affect the proper functioning of a thermostat. A recent case where trouble of this kind was encountered in a factory may be cited. The thermostat in this instance was mounted on the wall but in spite of all attempts at proper setting the heating system carried the temperature up to a point much higher than that necessary for comfort.

After due investigation, the thermostat was relocated on one of the building columns some distance away from the wall and this entirely cured the trouble. There were cold air currents descending along the wall on which the thermostat had been mounted, and these were responsible for the trouble.

Figuring the Horsepower of a Centrifugal Pump

Q. How can I determine the horsepower of a centrifugal pump?

Yonkers, N. Y. G. Gibson

A. The determination of the horsepower of a centrifugal pump is a simple matter if the discharge per minute and the head is known. Multiply the discharge in pounds per minute by the head in feet to give the total work done. The product of these two factors will be a certain number of foot pounds per minute, which is a measure of power.

One horsepower is, of course, equal to 33,000 ft. lb. per min., so that the horsepower of the pump may be found by dividing the work in foot pounds per minute by 33,000. In other words:

Hp. = lb. of water discharged per min. $\times$ discharge head in feet $\div$ 33,000.

The gross horsepower required to drive the pump will, of course, be greater than this amount, as allowance must be made for various hydraulic and mechanical losses, which vary in amount depending on the size and make of the pump and which are generally expressed in terms of efficiency. Thus to find the gross horsepower of a pump with an efficiency of 75 per cent, find the net horsepower as outlined above and multiply it by 100 $\div$ 75. This will then give the horsepower that will have to be supplied by the motor or turbine to operate the pump.

Wanted, a Work Schedule

I would like to have some assistance in devising a working schedule for a 5 day week, 8 hr. a day, 40 hr. all told. We are going to establish it in our plant. We will have five engineers, four men on regular shifts and one man only on the day shift but he may take the shift only one day a week since he will usually be kept on during the day for maintenance and minor repairs.

We would like to have several schedules to choose from and would like a scheme whereby each of the men would work five days on shifts, each of four men getting a full Sunday of at least 24 but maybe 48 hr. off.

It may be necessary to split one shift in two halves and one man might have to work two weeks on a shift before changing.

We now have a system based on 4 days and 48 hr. off but we have to come in on varying dates which is very confusing. We would like to arrange it so that 4 men can take shifts. The fourth man, of course, can be assigned to relief but it must not be forgotten that there is also a fifth man or repair man who can take a shift one day a week at least.

Any advice in devising a suitable schedule will be appreciated.

Newark, N. J. J. M.

Designs of a Continuous Blowdown System

Q. What factors must be taken into consideration in determining the size or the proportions of a continuous blowdown system?

Red Bank, N. J. A. P.

A. In general the size of the continuous blowdown system depends largely upon the concentration of the boiler water desired. This concentration determines the quantity of blowdown required for a given steaming rate and the initial concentration of salts in the boiler feedwater. The size of the boiler is of little importance in this case since the amount of water evaporated depends upon the rating at which the boiler is operated. The two prime factors therefore are, the steaming rate and the degree of concentration required.

Where Should the Water Level be Kept in Shutting Down Boilers?

Q. What is the proper practice in maintaining the water level in large boilers, particularly high pressure boilers, preparatory to shutting down? Is the boiler feed pump kept running? Is the water held in sight in the glass or is it permitted to go down as the water evaporates from the heat stored in the boiler and setting?

Chicago, Ill. W. F.

A. If the boiler is being taken off the line under normal conditions, general practice is to keep the feed pump running so as to keep the water level in

sight in the glass. Of course, if the unit is being shut down due to say a tube rupture, then it is permissible to shut the feed pump down.

In one case of this kind that came to our attention recently, a tube blew but the operators did not detect it, but found great difficulty in maintaining ignition on the pulverized coal burners. Then from the boiler meters they noticed that the boiler feed pump delivery was far ahead of the steam output and that led them to find the cause of their trouble.

Cooling Milk

Q. WHAT size refrigerating machine should be installed in a dairy which has to cool 1000 gal. of milk in three hours from 80 to 40 deg. if brine tank storage is used and the refrigerating plant runs 9 hr. per day? Assume radiation losses to be neglected. The specific gravity of the milk is 1.03.

Long Beach, Cal. T. McIlwain.

A. ONE gallon of water weighs 8.337 lb. Milk with a specific gravity of 1.03, therefore will weigh $1.03 \times 8.337 = 8.60$ lb. The total weight of the 1000 gal. of milk, thus, is

$$1000 \times 8.6 = 8600 \text{ lb.}$$

The specific heat of milk is 0.9.

Since the temperature of the milk must be lowered from 80 to 40 deg. F. or 40 deg. and each pound has a specific heat of 0.9, then the total heat to be removed will be

$$8600 \times 0.9 \times 40 = 309{,}600 \text{ B.t.u.}$$

However, by the use of the brine tank this is distributed over a period of 9 hr. The heat that must be removed from the brine tank per hr. will be 1/9 of 309,600 or 39,400 B.t.u.

12,000 B.t.u. per hr. = 1 ton of refrigeration.

To remove 34,400 B.t.u. per hr., therefore will require $34{,}400 \div 12{,}000 = 2.86$ tons of refrigeration.

Combustible in Refuse

Q. WHAT is the correct method of figuring the loss due to combustible in the refuse.

New York City. H. BUCK.

A. AN equation given in Gebhardts' Steam Power Plant Engineering[1] for the heat lost in the refuse.

$$h = \frac{h_c}{100}\left(\frac{ya}{100-y}\right)$$

where h = the heat loss in the refuse, B.t.u. per lb. of coal as fired.
h_c = the calorific value of combustile in the dry refuse.
y = the percentage of combustible in the dry refuse.
a = the percentage of ash in the coal as fired.

For the average boiler test, the calorific value of the combustible in the dry refuse may be taken as that of pure carbon, but for accurate results calorimetric determinations are necessary.

The loss may be expressed as a percentage of the heat content of the fuel by dividing both sides of the equation by h_4 the heat content of the coal as fired and multiplying by 100. For ordinary purposes where extreme accuracy is not necessary h_c may be taken as equal to h_4.

Another somewhat different equation is given as

$$X = \frac{100\ ay}{[(100-a)\ (100-y)]}$$

where X = the percentage of loss.

Assuming a coal having 10 per cent ash is so burned that the combustible in the dry refuse amounts to say 30 per cent, we have, with the first formula

$X = 100 \times h - h_4$
$= (h_c \div h_4) \times y \times a \div (100 - y)$
$= 1 \times 30 \times 10 \div (100 - 30)$
$= 300 \div 70 = 4.28$ per cent

With the second formula, X

With the second formula, X
$= 100 \times y \times a \div [(100 - a)\ (100 - y)]$
$= 100 \times 30 \times 10 \div [(100 - 10)\ (100 - 30)]$
$= 30{,}000 \div (90 \times 70) = 4.76$ per cent

The difference in these two equations lies in the fact that in the first the heating value of the combustible in the refuse is assumed the same as that of the coal as fired, while in the second this value is assumed equal to the heating value of the combustible in the fuel as fired.

Aside from the actual heat lost in the refuse the effect of unburned combustible may have an important bearing on the calculation of the performance of steam generating equipment. This involves a more comprehensive discussion of steam generator performance than can be presented here but the whole subject was thoroughly discussed in the articles by G. Campbell Kohlar and Adolph Johnson in Power Plant Engineering last year. These articles are listed as follows: 1. Effects of Unburned Combustible by G. Campbell Kohlar, page 299, May, 1938. 2. Effects of Unburned Combustible by Adolph Johnson, page 470, July, 1938. 3. Unburned Combustible—The Fued Continues. By G. Campbell Kohlar, page 598, Sept., 1938.

[1]Page 100. Sixth Edition.

Perhaps You Do Not Agree with These Answers

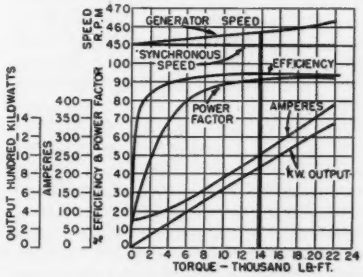
We answer these questions to the best of our ability and knowledge and within the limits of our resources, but we are human, at least we like to think so, and therefore we may make mistakes; also many questions involve differences of opinion and permit of several solutions all of which may be right. So if you do not agree with our answers or feel that you can answer questions more fully or in a different way, do not hesitate to write us. This department is your department and we want you to regard it more as a place for free discussion than as an information bureau. Editor.

Operation of an Induction Motor as a Generator

Q. CAN an ordinary induction motor be operated as a generator by driving it above synchronous speed by some external source of power such as a gasoline engine?

Minneapolis, Minn. H. K.

A. AN induction motor can operate as an induction generator but to do so, it must have its primary winding connected to a power supply of the proper phase, voltage and frequency before it can function. This is necessary because the excitation of an induction generator comes from the line to which it is connected. Synchronous machines connected to the same system supply this excitation. The voltage and frequency of the induction generator determined by the supply circuit to which the machine is connected, are the same as that of the supply circuit. The output of the machine depends upon the speed.



The characteristics of such an induction generator are practically the same as when the machine is used as a motor, except the speed as a generator is above synchronous speed while, as a motor it is below synchronous speed. If the speed of an induction motor at full load is three per cent below synchronous speed, the machine when driven three per cent above synchronous speed will deliver full load to the line. The accompanying chart shows the characteristics of a 1000 kv-a., 3 phase, 2300 v. 60 cycle, 457 r.p.m. induction motor.

Through the Air Heater?

Q. WHAT per cent of the total combustion air may be expected to pass through the air heater in a modern pulverized coal installation?

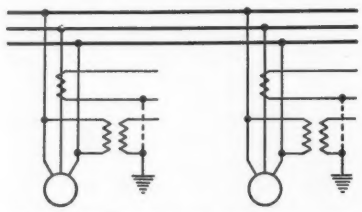
Houston, Texas S. B.

A. THIS, of course, varies in different installations and with different ratings but in general it will run from 80 to 95 per cent. In the case of certain tests that have come to our attention 80 to 85 per cent went through the air heater. On new jobs the percentage is somewhat higher

than on old installations. 95 to 100 per cent in the case of new installations, 85 per cent on old. In another recent test 100 per cent of the air passed through the heater at full load but this was accompanied by a 10 to 15 per cent excess gas temperature with a corresponding reduction in unaccounted for losses.

Grounding Secondaries

Q. WHERE generators are operated in parallel is it necessary to ground the secondaries of current and potential transformers used for voltage regulator service and for line drop compensation? In any case, whether they should or should not be grounded please explain why. In the installation I have charge of the reactance between the points regulated ex-



ceeds eight per cent and each generator has its individual voltage regulator; we therefore, use one current coil for each as shown in the accompanying diagram instead of two cross connected and one potential coil for each regulator.

Toronto, Canada. G. Rolph

A. THE instruments should be grounded for the same reasons that apply to the grounding of all instrument transformers; namely, that there is less danger to human life, and that, furthermore a fault in a transformer is more readily detected. The connections shown in your diagram are correct for generators which have separate voltage regulators, in fact it is the connection always used for such cases and no induction compensator is required because the voltage and current are already 90 deg. out of phase. The reactance value of eight per cent, between the regulator locations is sufficient to prevent excessive cross currents, even if no compensating arrangement were in use.

A Mystery Thriller— For the Indicator Experts

THESE TWO CARDS were taken from the No. 2 cylinder of a three cylinder Anderson two cycle Diesel engine pulling about ¾ load. They were taken with a 400 lb. spring and the cards above are 10 per cent smaller than the originals. The reducing motion is an eccentric on the layshaft, driven at the same speed as the crankshaft by a silent chain drive. No. 1 card was taken from the proper reducing motion; card No. 2 is for the same cylinder but using the reducing motion for another cylinder. (We don't know which one.)

What's the matter? Sorry, you have all the information we have at present except that at no load the loop A of card No. 1 is much larger than at full load. This is a good clue. Also, note that the compression and expansion lines cross

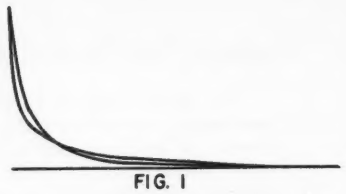


FIG. 1

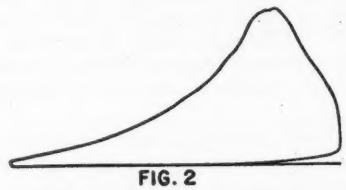


FIG. 2

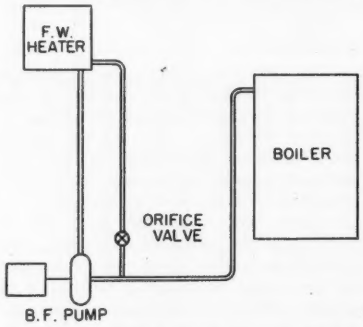
on card No. 1 and remember that on a three cylinder engine of this kind the cranks are 120 deg. apart and the usual firing order is 1, 3, 2.

Centrifugal Pump Discharge

Q. Is it dangerous to operate a centrifugal pump with the discharge valve closed?

Blue Island, Ill. J. Christofel

A. YES. If a centrifugal pump is permitted to run for any length of time with the discharge valve closed, the churning action of the impeller will generate heat and the consequent expansion of the internal parts may cause the bear-



ings to seize. Cold water can readily be heated to the boiling point in comparatively short time in this way. For this reason a centrifugal pump should not be operated for any length of time with the discharge valve closed.

In boiler feed pump practice it is desirable to guard against this possibility by providing relief or orifice valves on the discharge lines. As shown in the accompanying diagram, the orifice valve is installed in a by-pass line connected between the pump discharge and the feedwater heater. The orifice valve is fitted with a small orifice through which a small amount of water passes back to the feedwater heater, so that during times of low load when practically no water is being delivered to the boiler the water can circulate back to the feedwater heater in sufficient amount to prevent damage to the pump[1].

[1]Orifice valves of this kind are installed in the plant of the National Folding Box Co. described on page 500.

Pipe Friction

Q. WHILE TRYING to find the correct solution of the following problem I located a number of formulas but the answers given by them have all been different and I am not satisfied. The problem is: How many gallons of water will be delivered at the end of a pipe 4 in. in dia., 5280 ft. long, with a pressure of 40 lb. per sq. in. at the inlet end? The pipe is on the level with no bends and no elbows.

A. FRICTION formulas or pressure loss tables can be found in practically all books on hydraulics. The pressure loss will vary approximately as the square of the velocity but the exact value will depend upon the interior condition of the pipe. The following is a section of the pressure loss table for 4 in. pipe taken from the Standards of the Hydraulic Institute[1] and the friction figures are based upon 15 yr. old cast iron pipe. The capacity is in gallons per minute, the velocity in feet per second and the friction in head loss per 100 ft. of pipe.

G.P.M.	Vel.	Friction
50	1.28	0.34
75	1.92	0.73
100	2.55	1.22
120	3.06	1.71
125	3.19	1.86
150	3.84	2.55

Inasmuch as a pressure of 1 lb. per sq. in. is equivalent to a column of water 2.31 ft. high, 40 lb. pressure at the inlet is equivalent to a head of 2.31 × 40, or 92.4 ft. This head, if we assume is all used up in friction, is equivalent to a pressure drop of 92.4/52.8 or 1.75 ft. per 100 ft. of pipe.

Looking at the table it will be seen that this friction value lies somewhere between a value of 1.71 for a capacity of 120 g.p.m. and 1.86 for a capacity of 125 ft. The exact value can be found by plotting the data on a curve, or it can be calculated on the assumption that the friction loss varies as the square of the velocity. In this case the desired velocity is

$$\text{vel.} = V3.06^2(1.75/1.71) = 3.10$$

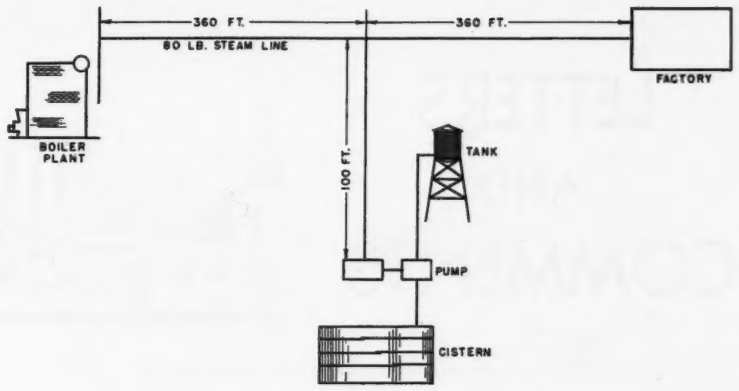
Having determined the velocity, the corresponding discharge or capacity can be calculated on the assumption that the capacity varies directly as the velocity. The capacity is, therefore,

$$\text{g.p.m.} = 120\ (3.10/3.06) = 121.5$$

The accuracy of the tables do not, however, justify such close calculation. With new, clean pipe the friction head will be considerably less than with old pipe and the discharge correspondingly greater. Friction tables which are based upon experimental data usually refer to old pipe. Consequently, the pipe size as calculated from this is generous while the pipe is new. The advantage of using the higher friction figures lies in the fact that a pipe so calculated will be large enough for the required capacity after the inside becomes dirty or corroded.

Selection of pipe size is a matter of economics, that is balancing the increased cost of larger pipe against the increased pumping cost for small pipe.

[1]These standards can be purchased from The Hydraulic Institute, 90 West Street, New York City. Price $1.00.



How Would You Do It?

IT IS TOO early at the time of this writing to announce the winners in last month's problem contest since the "deadline" is still two weeks off. We have received a number of interesting solutions but not as many as we had hoped for. It may be due to the nature of the problem or it may be merely the hot weather that is responsible for the apparent lack of interest but whatever it is, we hope that it will not remain a permanent condition. Prize contests, we realize are somewhat a "pain in the neck" these days when every radio program is either a quiz program or prize contest of some sort, and we ourselves are somewhat fed up on them.

In the ordinary course of our editorial routine however, we receive a great many comments and questions regarding operating problems and we felt that interest in such problems and their solution could be stimulated by offering the additional incentive of a small prize. As announced last month, in this case we offer a prize of fifteen dollars for the first prize and a set of power plant handbooks as the second prize.

PROBLEM No. 2

This month we find our hero perplexed over the location of a pump. This pump, pumps water at 60 deg. F. from a cistern to an elevated tank. It operates at a steam pressure of 80 lb. per sq. in. and delivers 250 g.p.m. against a 70 ft. head.

The pump and tank is located about 360 ft. from the boiler and takes steam from a line extending between the boiler and the factory. This line is 700 ft. long and the pump is tapped into it by a line 100 ft. long at a point midway between the boiler and factory. The arrangement is clearly shown by the sketch at the top of this page.

The question in our hero's mind is whether it would prove economical to install this pump at the boilers where 130 lb. steam pressure is available. If it were moved to this location it would be necessary to run a 4 in. suction line to the cistern and a 3 in. discharge line to the tank, both of which would be about 360 ft. long. The object of the arrangement would be to avoid condensation losses in the 100 ft. steam line from the main steam line to the pump. This line is outdoors.

Naturally he does not want to go to the expense of installing the two water lines unless a material saving in fuel would result. Neither the cistern nor the tank can be moved so they will remain in their present locations.

What would you do in this case? Would you move the pump or would you do something else?

Our own reluctance toward entering prize contests is based, more or less, upon a knowledge of the great odds against us. In the case of a radio prize contest reaching millions of listeners among which there are thousands who have little else to do but enter prize contests, it seems almost futile to enter it.

In this particular contest being conducted on this page, however, your chances of winning are many times greater than in any general prize contest. To begin with, there can be few among our readers who might be classified as professional contest fans; secondly, our circulation (the number of individuals reached) is very much smaller; and finally, the solution of the problems often demands specialized knowledge which is not possessed by more than a small number of the readers for any particular case. Your chances of winning one of the two prizes in this contest awarded each month are therefore many times greater than in any "general" contest.

We urge you, therefore, to try your hand at the solution of these problems. The one presented here, we believe, is somewhat more specific than Problem No. 1 presented last month and, also, it probably permits of greater difference of opinion. It is, as a matter of fact, an actual problem that came up in the experience of one of our readers and he appealed to us for assistance in solving it. In attempting to solve it, therefore, you can have the satisfaction of knowing that you are working on something that actually arose in practice—something that might have come up in your own plant.

And that reminds us to invite you again to submit problems that *do* arise in your own work. Even though you may have effected a satisfactory solution to such problems, they may permit of other solutions and we think that you will find it of interest to see how others would attack them.

LETTERS AND COMMENTS

Corrosion of Underground Pipe

THE article on page 406 of the June issue is one that deserved to be brought to the attention of all industrial plant men. I refer to the one headed "Sand Helps Check Water Main Electrolysis". I do not mean that electrolysis is so common but the matter of water and other pipe line corrosion is much more prevelant than it should be.

Corrosion itself is bad enough but the cost of the pipe itself is but a small item of the expense involved in changing it. Even in extremely bad cases the pipe will last 8 or 10 yr. and in the meantime those who laid the pipe have often gone elsewhere so that its exact location is unknown. Then again the new building may cover a major portion of roadways, and other pipe and conduits may make replacement decidedly inconvenient. In fact it is often best to forget the old line entirely when it gets to leaking badly and just put in a new one.

Much of the corrosion can be laid to the use of ash and clinkers in the backfill. Most engineers and contractors recognize that at least some drainage is desirable. They also know that cinders make excellent fill, that they drain well and make excellent roadways. What they forget, and they must forget or cinders would not be used so often, is that cinders have a high sulphur content and in the presence of water are extremely corrosive because of the formation of sulphuric acid.

A good practice to follow is to backfill the trench with a foot or a foot and a half of coarse sand, lay the pipe and then add another foot or foot and a half of sand on top before putting back the original soil. Also when doing this be sure that cinders from old roadways and walks are not included. If a lot of buildings and pavement are involved it is worth the extra expense to include a layer of crushed rock under the pipe to facilitate drainage and to pitch the trench slightly so that water can get away. After all, when you lay a pipe line you expect it to give service for 20 or 30 yr. and a little extra care and effort is justified.

Brooklyn, N. Y. P. F. ROGERS

Chemistry—A Part of Every Engineer's Training

The successful power plant man must be many sided—engineer, psychologist, economist and teacher. Chemistry is one branch of engineering used every day.

FROM TIME to time there have appeared articles dealing with the qualifications of power plant engineers. With the growth of the power industry, the standard of these qualifications has steadily risen. Most of these articles have dealt mainly with the engineering side of the profession. This probably arises from the fact that the power plant operator must first of all be an engineer, in every sense of the word. His training, experience and ability must be broad and thorough.

There are, however, other qualifications which, while not as important, are not only desirable but necessary. These are not peculiar to this field only. The fact that a little knowledge can be dangerous implies that we cannot learn too much. Being only an engineer does not guarantee that the plant operator will be successful. As the head of an organization, his dealings with his coworkers require tact, diplomacy and understanding. For this reason, many an engineer has wished he was a psychologist or perhaps a psychiatrist. The economic aspects of power require the talents of an accountant and economist. Training employees requires teaching ability. Since we are here concerned with the successful power plant engineer, we can expect him to be well versed in all the above subjects.

It is here proposed to show how a knowledge of chemistry can be of real help. Many problems of power generation are of a chemical nature. The chemistry of power can be said to begin at the coal pile. The selection of coal, while often governed by past experience may have to be decided by analysis, in which case it would be necessary to interpret properly the coal analysis report.

After the fuel has been selected, the problems incidental to combustion arise and a knowledge of the chemistry of combustion must be thoroughly understood in order to use the fuel most efficiently. It is not unlikely that dry ice and sulphur dioxide will soon be by-products of most power plants. The extraction of these products from chimney gases involves the problems of combustion and offers another opportunity for the operator to apply his training in chemistry.

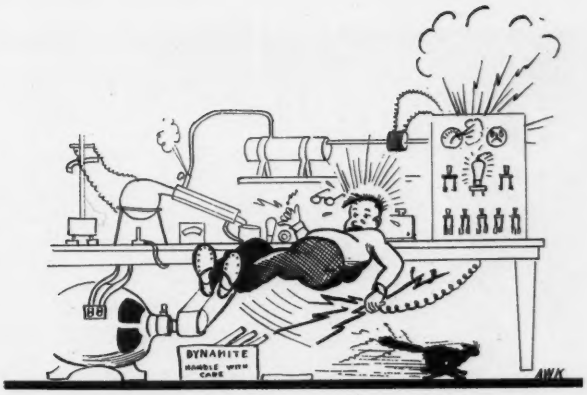
So much has been written on the subject of water treatment that its importance is now generally recognized. The average plant operator is not in a position to do much research on this problem, but unless he is familiar with the reactions that take place, his application of the treatment prescribed will not be intelligent and his troubles from this source will be multiplied. The effect of improperly treated boiler water is not limited to the boiler alone, but involves water and steam lines, turbine blading, auxiliary steam equipment, condensers and pumps, in fact all equipment that comes in contact with the water, steam or condensate. Attacking problems of scale formation, feed line deposits, embrittlement, priming, foaming, carryover, blade deposits, corrosion and corrosion fatigue will be futile unless the chemistry involved is understood. In the field of water treatment, the power plant engineer will perhaps find his knowledge of chemistry most valuable.

Research by most of the oil companies has resulted in excellent and reliable lubricants. Nevertheless, even the best oil can fail. A knowledge of the more simple tests for lubricants can prevent the shutting down of equipment from this cause, as well as make a saving where it is the practice to change oil periodically regardless of its condition.

It is not assumed that the power plant operator will be able to solve all of his chemical problems or do very much research by his own efforts, but a knowledge of chemistry will be of inestimable value in getting the most from reports of colleges, universities and various organizations doing research work on the power industry's problems. It will also be of great help in giving information and assistance to those doing such research.

Green Bay, Wis. A. A. HALTUG,
Mechanical Engineer,
Wisconsin Public Service Corp.

. . . SHORTS . . .



Rubber may be rubber to you but the Hewitt Magazine, the new house organ of the Hewitt Rubber Co., says a properly compounded rubber is only part rubber. A typical recipe which properly vulcanized gives a compound with a tensile strength of over 4000 lb. per sq. in. (as compared to less than 300 lb. for unvulcanized crude rubber) is only 60 per cent smoked rubber sheet. There are; 31 parts of carbon black to give high tensile strength and abrasion resistance; 1.8 parts of sulphur for vulcanization; one part of pine tar for tack and smooth processing; and various amounts of zinc oxide, stearic acid, phenyl-beto-naphylamine, mescapto-benzothiazole and sunproof to improve the aging properties, accelerate the cure and resist deterioration due to ultra-violet rays of the sun.

* * *

The three-year old 800 lb., 750 deg. F. Goodyear boiler at Akron has, according to C. W. E. Clarke, an overall efficiency ranging from 87.5 per cent at 100,000 lb. per hr. down to 82.5 per cent at 300,000 lb. per hr. This is a cross drum boiler with slag tap furnace burning Pittsburgh No. 8 coal with a maximum heat release of almost 33,000 B.t.u. per cu. ft. per hr. The furnace temperature at this load is about 2500 deg. F.

* * *

A Centrifugal Filter employs the principle of centrifugal sedimentation, and requires no filter screens or cloths. Solid particles to be removed from the liquor may be as large as 3/8 inch mesh or as fine as a fraction of a micron. Capacity ranges up to 10 to 21 tons of solids per hr., depending on particle size, percentage of solids, and specific gravity.

* * *

A Mixing Machine is reported to divide materials into thirds by geometric progression. Material fed to the blender enters first a single screw flight, then a double, and finally a triple. At this point material is divided into three streams. Four cycles on the machine cause 81 divisions.

* * *

A New Alloy has been developed in cast and wrought forms for current-carrying parts in electrical equipment. It contains copper, chromium, and lithium. It is reported that the lithium serves to deoxidize the copper melt, preventing the formation of chromium oxides, which are deleterious in alloys intended for this type of service.

* * *

Cork, one of the most prominent of insulating materials and widely used in many other fields, is curiously one of the least known of all natural products. Ask ten people to tell you what cork is and where it comes from. If half are right, the percentage of correct answers is high.

Cork is the spongy outer bark of the cork oak tree. These trees flourish on the mountainous slopes of Portugal, Spain, Algeria and other countries around the Mediterranean Sea. When the tree attains the age of 20 or 25 years, the outer bark, which is the cork, is stripped off. The stripping does not hurt the tree. It grows another thick skin in nine or ten years and this is stripped off. The tree lives for more than a hundred years and produces a crop of cork every nine of ten years during its lifetime. Each new crop produces better and more uniform cork.

* * *

Four-fifths of the world's inventions are produced in the United States each year, says the editor of Central Manufacturing District Magazine. Within the last 50 yr. no less than a million new products have been placed on sale in the retail stores of the nation and competent authorities say the day of new industrial products has only begun.

* * *

A series of tests to determine a method of locating a "dying" high voltage, underground, electric cable before complete failure takes place are being conducted at Johns Hopkins University, it is disclosed in a report by the Engineering Foundation.

The studies, said to be of paramount importance to utilities, seek to eliminate the explosions which sometimes accompany cable breakdowns.

Preliminary warning of the complete destruction of a cable would also permit power companies to control indirectly the time element in making repairs, leading to higher efficiency and reduce costs of replacements.

Since inception of the project at Johns Hopkins, approximately seventy-five cable specimens have been constructed, treated according to commercial practices, and tested to destruction. The high degree of success attained is largely due to the use of a specially prepared high-speed voltage interrupter, which removes the voltage from the cable at the instant that breakdown begins. Consequently, since a finite time is necessary for the breakdown to proceed through the entire insulation wall, the progress of destruction is interrupted long before complete failure occurs, and the point of initiation of failure is easily detected by post-mortem examination.

* * *

The annual report of the Electricity Commissioners of Great Britain for 1938 which has just been issued shows that the output of the 374 stations of the authorized electric supply undertakings amounted to 24,372 million kw-hr., an increase of 6.4 per cent over that of 1937. Steam-operated plants were responsible for just over 95 per cent of the total, the quantity of coal consumed being given as 14,186,000 long tons. With regard to the fuel efficiency attained the return shows that based on the amount of power sent out, this worked out at only 1.45 pound of coal per kw-hr. as compared with 1.51 pound per kw-hr. in the previous year. The figure for plants with outputs over 200 million kw-hr. averaged 1.3 pound per kw-hr., the best result (0.9 lb.) being achieved by the Battersea station of the London Power Co. As to overall thermal efficiency the best individual performance (27.85 per cent) was achieved by the Dunston "B" plant in North-Eastern England which has been in operation since 1933. It is considered that a good deal of the credit for this achievement must be given to the flue-gas reheating of steam between the high and low pressure cylinders of the turbines.

* * *

Combined expenditures of the Detroit Edison Co. and Consumers Power Co. for 1939 will total in excess of $25,000,000. Much of this sum will be used to replace obsolete equipment, yet plans call for the construction of new projects in various parts of the State of Michigan.

COST OF PUMPING WATER WITH ELECTRICITY
CQ = COST OF PUMPING 1000 GALLONS — CENTS
Q = GALLONS PUMPED PER MINUTE
CH = CENTS COST PER HR. – PUMPING AT CAPACITY Q
R = COST OF ELECTRICITY PER KW. HR. – CENTS
KW = KILOWATT INPUT TO MOTOR
EM = MOTOR EFFICIENCY
BR. HP. = BRAKE HORSEPOWER OF MOTOR
EP = PUMP EFFICIENCY
W.HP. = WATER HORSEPOWER
H = HEAD IN FEET
PRESSURE IN LB. PER SQ. IN.
Q = PUMP CAPACITY IN GALLONS PER MINUTE
MILLIONS OF GALLONS PER DAY OF 24 HR.
ILLUSTRATIVE PROBLEM
GIVEN DATA
Q = 2000
H = 100
EP = 075
EM = 085
R = 15
Q = 2000
CHART DETERMINATIONS
W.HP = 505
BR HP = 6747
KW = 5921
CH = 8882
CQ = 074
EQUATIONS SOLVED BY USE OF CHART
W.HP = H × Q / 3960
BR HP = W.HP / EP
KW = BR HP × 0.746 / EM
CH = KW × R
CQ = CH × 16.67 / Q

Smoke and Fly Ash Prevention

Design considerations and test data on smoke and fly-ash prevention at the Federal Central Heating plant at Washington.

By J. F. BARKLEY

Supervising Engineer, Fuel Economy Service,
U. S. Bureau of Mines, Washington, D. C.

THE DECISION to install in Washington a Central Heating Plant to serve and be set near the many monumental buildings, Federal and otherwise, brought to the forefront the problem of the prevention of the emission of damaging smoke and fly-ash. The carrying out of any methods adopted also had to permit an architectural exterior appearance of the plant that harmonized with the surrounding buildings.

Economic considerations established the fact that coal should be the fuel used and the plant was designed to be able to burn slack coals ranging in volatile content from low to high. A decision as to the type of coal-burning equipment had to be made between underfeed stokers and pulverized fuel. Many considerations of various kinds influenced this decision. From the standpoint of smoke emission, the underfeed stoker has an inherent fundamental advantage in that, with its use, the temperature of the coal is raised rather gradually and slowly evolves its volatile matter, which passes upward through hot coke to be burned. It was considered that less ash would leave the boiler and that it would be a simpler matter to obtain ash-free stack gases. So underfeed stokers were finally chosen.

The next important step relating to smoke and fly-ash was the sizing of the stokers. These stokers were sized unusually large for the loads to be carried. The quantity of coal now burned per square foot of projected stoker area ranges from about 30 to 45 lb. per hr. The per cent ash in the coal is about 8.5 per cent as received. Table I illustrates the importance of the amount of coal burned per hour per square foot of grate area upon the total amount of fly-ash leaving the boiler.

This table shows that increasing the fuel rate per square foot of grate area about three-fourths or from 23.0 to 40.5 lb. increased the percentage of fly-ash leaving the boiler about 3.8 times or from 0.73 to 2.80 per cent. It also shows considerable variation in the fly-ash emission at the same fuel burning rate as would be expected considering the many variable factors.

The setting height of the boiler or the height of the front header above the floor is unusually high, thus giving extra-long flame travel. After the furnace volume was calculated and the height of this header determined from the usual standards, it was arbitrarily increased 2 ft. or about 14 per cent as an extra safeguard. The heat release ranges from about 21,000 to 31,000 B.t.u. per cu. ft. of furnace volume per hour. Sidewall water cooling and clinker grinders were installed. These features help eliminate many possible stoker operating difficulties in handling ash that would readily lead to the production of smoke.

Such design will not, of course, in itself eliminate smoke. Wherever other than an inherently smokeless fuel is being used, there always exists the opportunity to make smoke from the manner in which the equipment is operated. After installation, the operators were given a long training period in handling the equipment. A recording smoke indicator was installed at the boiler front to show any production of smoke leaving the boiler. The operator's problem is to keep this instrument showing clear, or practically clear.

To eliminate smoke and fly-ash acceptably, however, more features were needed. Operators are not perfect. It is necessary to blow boiler tubes at periodic intervals. Vein-type cinder catchers to catch the heavier fly-ash particles were installed. It was further necessary to add equipment to catch the lighter particles of smoke and fly-ash that get by the cinder catchers. Two different principles of accomplishing this purpose were given consideration at the time, the electrostatic and the washing or scrubbing of the products of combustion with water.

Various schemes of the latter type were studied, together with their possibilities of removing sulphurous gases, which is not possible with the electrostatic principle. Although the coals apt to be used at this plant have relatively low sulphur content, the desirability of removal of sulphur from the products of combustion was appreciated. From a general standpoint, it is probable that the economic importance to a community of eliminating sulphur from products of combustion, particularly where high sulphur coals are used, will some day result in proper measures being taken, particularly as regards large plants.

Possibly if this plant had been planned some years later, other principles of removing smoke and fly-ash would have been considered.

An electrostatic-type precipitator was finally chosen and while space consideration caused it to be of special design[1] it has proved quite satisfactory in operation in eliminating smoke and fly-ash. In the design of the Central Heating Plant, space limitations required that any cleaning equipment chosen must not occupy much space for the building height could not be increased due to building regulations for that area. From the standpoint of other considerations, the height had already been lowered some 15 ft. by means of excavation.

Table II gives test data on the elimination of fly-ash from the products of combustion by the cinder catcher and the Cottrell precipitator. At the lower ratings the cinder catcher removed about 50 per cent of the total fly-ash and at the higher ratings about 35 per cent. Under average operating conditions it is estimated that not more than about 4 to 5 per cent of the total fly-ash goes into the atmosphere. This is about 0.03 to 0.15 per cent of the total weight of the coal fired.

TABLE I.—Test Data on Fly-Ash Emission at Boiler-Outlet Damper

Test No.	1	2	3	4	Ave.	5	6	Ave.
Lbs. coal burned per sq. ft. of grate area per hr.	23.00	23.00	22.90	23.20	23.00	40.40	40.60	40.50
Total lbs. coal burned per hr.	11,268.00	11,259.00	11,217.00	11,376.00	11,280.00	19,812.00	19,912.00	19,862.00
Total lbs. per hr. or fly-ash leaving boiler	79.50	62.30	101.40	86.10	82.40	666.40	447.30	556.90
Percent of total fly-ash to total coal	.71	.55	.90	.76	.73	3.36	2.25	2.80

TABLE II.—Test Data on Elimination of Fly-Ash from Products of Combustion by Cinder Catcher and Cottrell Precipitator

Test No.	1	2	3	4	Ave.	5	6	Ave.
Total lbs. per hr. of fly-ash leaving boiler	79.50	62.30	101.40	86.10	82.40	666.40	447.30	556.90
Total lbs. per hr. of fly-ash caught by cinder catcher	39.60	30.10	49.40	44.30	40.90	250.00	144.10	197.10
Total lbs. per hr. of fly-ash caught by Cottrell precipitator	36.70	29.60	47.80	38.50	38.20	383.10	278.90	331.00
Estimated lbs. per hr. of fly-ash going to atmosphere. (Based on special tests on precipitator)	3.20	2.60	4.20	3.30	3.30	33.30	24.30	28.80
Percent of total fly-ash caught by cinder catcher	49.80	48.30	48.70	51.50	49.60	37.50	32.20	35.40
Percent of total fly-ash caught by Cottrell precipitator	46.20	47.50	47.10	44.70	46.40	57.50	62.40	59.40
Percent of total fly-ash going to atmosphere	4.00	4.20	4.20	3.80	4.00	5.00	5.40	5.20
Percent of fly-ash going to atmosphere to total coal	.028	.023	.037	.029	.029	.168	.122	.145

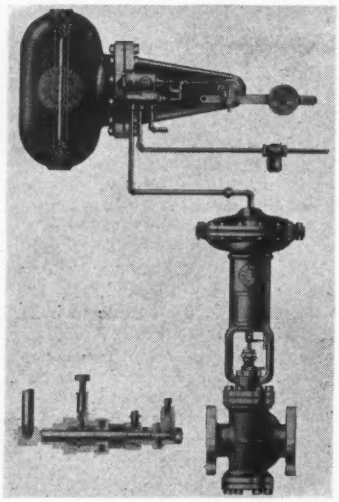
[1]For details see article by C. W. Hedberg, Mechanical Engineering, page 25, Vol. 58, No. 1, 1936.

New Equipment

Information that you desire about any equipment will be gladly furnished without obligation. WRITE POWER PLANT ENGINEERING.

Liquid Level Controller

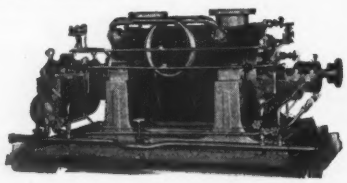
THE KIELEY & MUELLER CO., New York, N. Y., announces its Liquid Level Controller line which is manufactured in floats from 6 to 12 in. Bodies of cast steel, semi-steel, alloy steel and other special construction, including a special method of lead lining for acid services. The ball bearing stuffing box construc-



tion includes at KA_2SMO stainless steel one piece shaft removable from the stuffing chamber without breaking the connection of the box in the float chamber. Almost complete lubrication is had on the shaft and there is a minimum of metal to metal contact. These controllers are available in direct connected, pilot operated and in conjunction with air operated instruments.

Centrifugal Pump

THE PACIFIC PUMP WORKS, Huntington Park, Cal., has recently introduced a new type boiler feed, multi-stage, double case, centrifugal pump which will handle temperatures up to 850 deg. F. and differential pressures up to 2500 lb. This pump is finished with forged steel shell, end covers and nozzles. They are built for capacities from 50 gal. per min. to 2700 gal. per min. to meet either low or high suction pressure conditions.



Design features include balanced floating seals for high suction pressure, high temperature conditions as well as an arrangement of both mechanical and floating seals to meet these same conditions. Stuffing boxes are provided with a double cooling system which insures long life to the packing and maximum safety. Mixed flow impeller veins extend out into the suction eye and low suction velocities are obtained through the design of large suction bay and the large area first stage impeller.

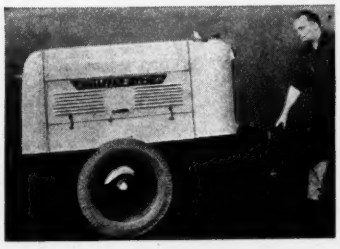
Welder

THE HARNISCHFEGER CORP., Milwaukee, Wis., announces the new P&H Hansen Model WA-200 square frame welder for multi-arc service. It is a precision built welder whose design enables it to be built with the practical economies of modern mass production. The WA-200 requires less than 3½ sq. ft. of floor space, offers a welding range from 40 to 225 amps. Retaining all the inherently fine characteristics made possible by the Hansen patents which cover automatic volt ampere regulation, self excitation and internal stabilization of the welding current, the WA-200 is built along extremely simple lines, having but two major parts, the one piece frame and the rotating member itself.

All attachments such as external exciters, reactors, resistors, rheostats or separate stabilizers are absent. Spring-mounted louvres can be snapped on and off to make periodic inspection of brushes and commutator or for minor adjustments. Top and plates are also easily removed. With the new type of patented frame promoting extremely rigid construction and designed to protect bearings against misalignment and wear, vibration is noticeably absent. The rotating member is statically and dinamically balanced. Owing to its unique design, it may be used in multiple service when necesssary. Where a wider welding range is desired, these units may be hooked in parallel without special adjustments to gain any desired welding amperage.

Lightweight Portable Compressors

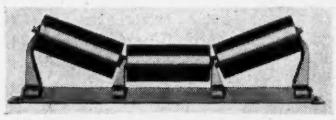
THE SULLIVAN MACHINERY CO., Michigan City, Ind., announces the addition of a completely new line of portable air compressors known as the Zeph-air. Two sizes are available with capacities of



60 and 85 cu. ft. per min., respectively, of delivered air. Although these compressors have capacity to operate concrete breakers and rock drills, they are so small and compact that the two-wheel mountings can be towed by a pleasure car and the skid-mounted models can be mounted in the body of standard pick-up trucks.

Ball-Bearing Idler

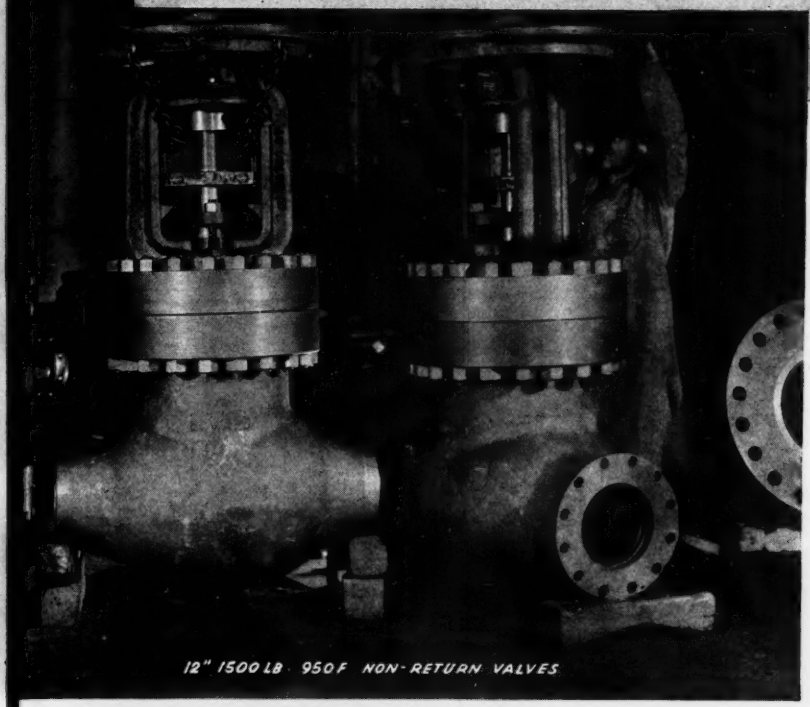
A BALL-BEARING IDLER, designed as type B-304, for handling materials of medium weight consisting of fines and small lumps, has been developed by the Chain Belt Co., Milwaukee, Wis. It is suitable for conveyor widths of 14 to 30 in. inclusive. The idler rolls are made from 4 in. diameter smooth finished steel tubing with formed heads pressed into and welded to each end. The heads are ball-bearing equipped with effective sealing against dust and dirt by a combination



labyrinth and composition seal. The rolls are rounded and smooth to prevent injury to conveyor belt and may be quickly removed. High pressure lubrication is provided for either or both ends of the idler by means of button head grease fittings which are regularly furnished. The troughing idler rolls are supported in strongly ribbed brackets of unbreakable malleable iron construction. The brackets are in turn supported on an inverted angle base which is self-cleaning with no shelves or pockets for dust accumulation.

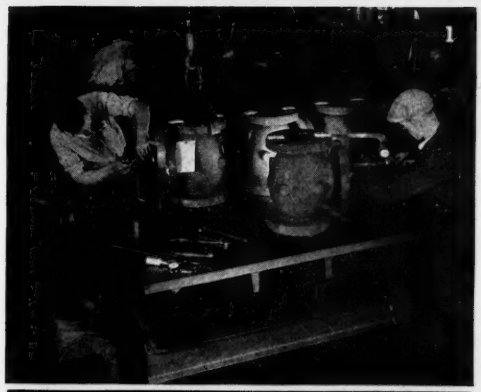
Choosing Materials for Edward Valves-No. 10 of a Series

ETERNAL VIGILANCE IS THE PRICE PAID FOR GOOD VALVE CASTINGS

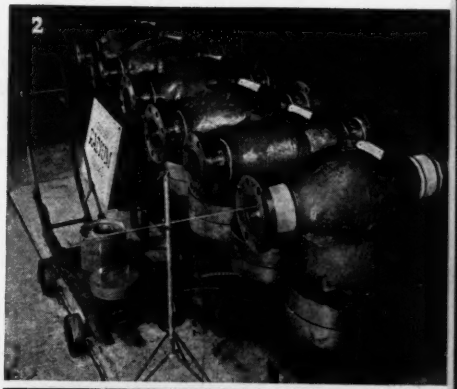


12" 1500 LB 950 F NON-RETURN VALVES

NO formula assures the kind of steel castings needed for high pressures and temperatures. There are too many variables to permit blind adherence to a single technique. Each pattern presents a problem of its own. The human element also may send results haywire. Eternal vigilance is the task of the Edward technical staff which has dealt for years with the most severe working conditions known. There is a knack to detecting sub par castings, in which Edward testers excel. Uncertainty is minimized when buying Edward.



1. SHRINKAGE problems related to molten steel make production of true-to-dimension castings an intricate matter. Photo shows steel castings undergoing dimensional and visual inspection. Magnetic tests are also made to detect minute surface flaws.



2 GAMMA RAY technique helps find possible hidden discontinuities. These check valves are to be provided with welding ends. Temporary test flanges, located well outside finished end to end dimensions, permit thorough hydrostatic test. Two radium capsules are being used simultaneously, one at each end. A typical Edward application of research to production.

3 WELDING ENDS with various V or U grooves are specified by engineers for cast steel valves. In the case of the valve illustrated, from which test flanges are being removed after pressure tests, tapered backing ring is to be employed in field welding.

4 DESTRUCTIVE test of Edward steel castings is afforded by sectioning and deep etching the temporary test flanges. If, after subjection to hot acid, porous areas appear in test flanges desirability of radiographic examination of adjacent portion of casting is indicated. Pieces are saved for micrographic, physical and chemical analysis. Cut shows metallurgist examining test flanges for 4", 6" and 8" 900 lb valves.

THE EDWARD VALVE & MANUFACTURING CO., INC. EAST CHICAGO, INDIANA

EDWARD VALVES

Stop · Check · Blow-off · Non-return · Feed Line · Relief · Bleeder Line · etc.

Push-Button Control Stations

A NEW line of standard duty, Bulletin 800 push-button control stations has just been developed by the Allen-Bradley Company, 1311 S. First Street, Milwaukee, Wisconsin.

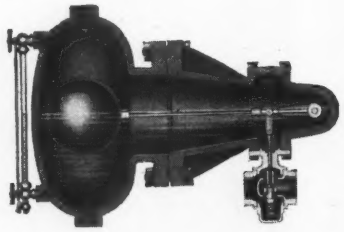
The new Bulletin 800 stations are available in single-button and double-button types. They are styled to harmonize with modern machinery.

The new Bulletin 800 push-button stations are available in both the horizontal and vertical arrangements. They have a maximum d.c. rating of amp., 115 v.; 0.5 amp., 230 v.; 0.25 amp., 550 v. Maximum a.c. rating: 3 amp., 110-220-440-550 v.

Boiler Feedwater Regulator

THE MCALEAR MFG. CO., 1901 S. Western Ave., Chicago, has announced a series of improved feedwater regulators for steam boilers known as Nos. 906, 907, 936 and 966.

Regulator No. 906 maintains proper levels in individual boilers supplied by steam pumps which are controlled by governors such as the McAlear No. 500 Excess Pressure Pump Governor. For applications where electric motor driven pumps are used, instead of steam pumps, to supply the boiler feedwater, Regulator No. 936 is recommended. It is equipped with a low-water cutout switch, but otherwise is similar to No. 906.

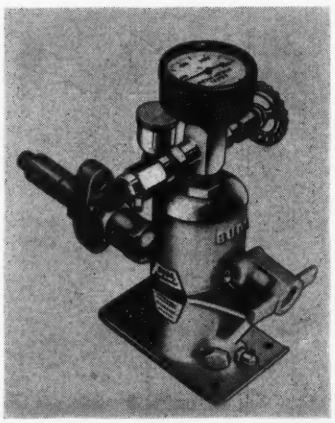


Regulator No. 966 also is similar to No. 906 except it is equipped with a combination low water cutout and pressure switch. Regulator No. 907 is used when it is desired to employ the feed valve to regulate the flow of steam to a steam-driven pump and thus maintain the proper level in the boiler. Although the other regulators in this series permit several boilers to be supplied by a single pump, No. 907 Regulator is suited only to applications in which boilers are supplied by individual pumps.

All regulators in this series are constructed of semi-steel, with stainless steel float and trim, for pressures up to 250 lb., and of cast steel, with stainless steel float and trim, for pressures of over 250 lb.

Nozzle Tester

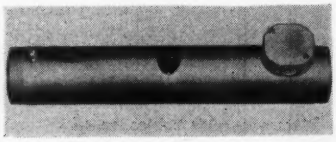
THE BUDA CO., Harvey, Ill., announces the Buda Hydraulic Nozzle Tester, a precision instrument for accurately testing Diesel fuel injection nozzles manufactured by Bosch, Timken, Deco and others. Operation of the tester



requires no specialized knowledge and any mechanic can clean and adjust nozzles at minimum time and expense. The tester is 10¾ in. high and weighs 12 lb. It may be mounted permanently on the work bench or carried in a light weight carrying case provided for this purpose. The tester fitted in the case lists at $25.00. It is described more fully on a two-page bulletin, No. 958.

Electric Valves

THE WHEELCO ELECTRIC VALVE, series 1223, which has recently been added to the Wheelco line is a self contained, electric control valve for throttling of gas, oil or air flow to furnaces, ovens and similar heating applications. Com-



bining the valve and the operator in a simple totally enclosed unit, the electro thermal expansion principle of the Electric Valve achieves outstanding control performance without mechanical movement other than the expansion and contraction of the enclosed operating cylinder. Once installed and adjusted, this device it is claimed will render accurate service for years without requiring further attention.

The valve functions on the difference in thermal expansion between two metal cylinders. The operating cylinder contains an electric heating element of low thermal capacity. When current is applied to the heating element, the resulting increase in temperature elongates the operating cylinder moving the integral disc away from the disc which is permanently fixed to the outer or compensating cylinder thus permitting passage of the fuel. The openings or holes in the discs are arranged in staggered position. The degree of flow is governed by the amount of separation permitted between the discs by the expansion or contraction of the operating cylinder. Minimum flow adjustment is accomplished by screw adjustment.

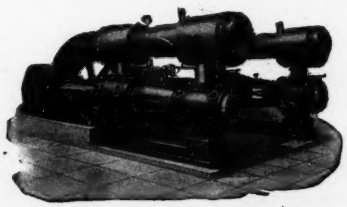
The Wheelco electric valve is made in various sizes and for either 110 v. or 220 v. a.c. or d.c. by Wheelco Instruments Co., 1929 S. Halsted St., Chicago, Ill.

Air Compressors and Vacuum Pumps

CHICAGO PNEUMATIC TOOL CO., 6 East 44th St., New York, N. Y., announces two new machines. The first is the Class O-CTE horizontal tandem duplex compressors. These machines are motor driven and are identical with the Class O-CE as described in Bulletin 726, except

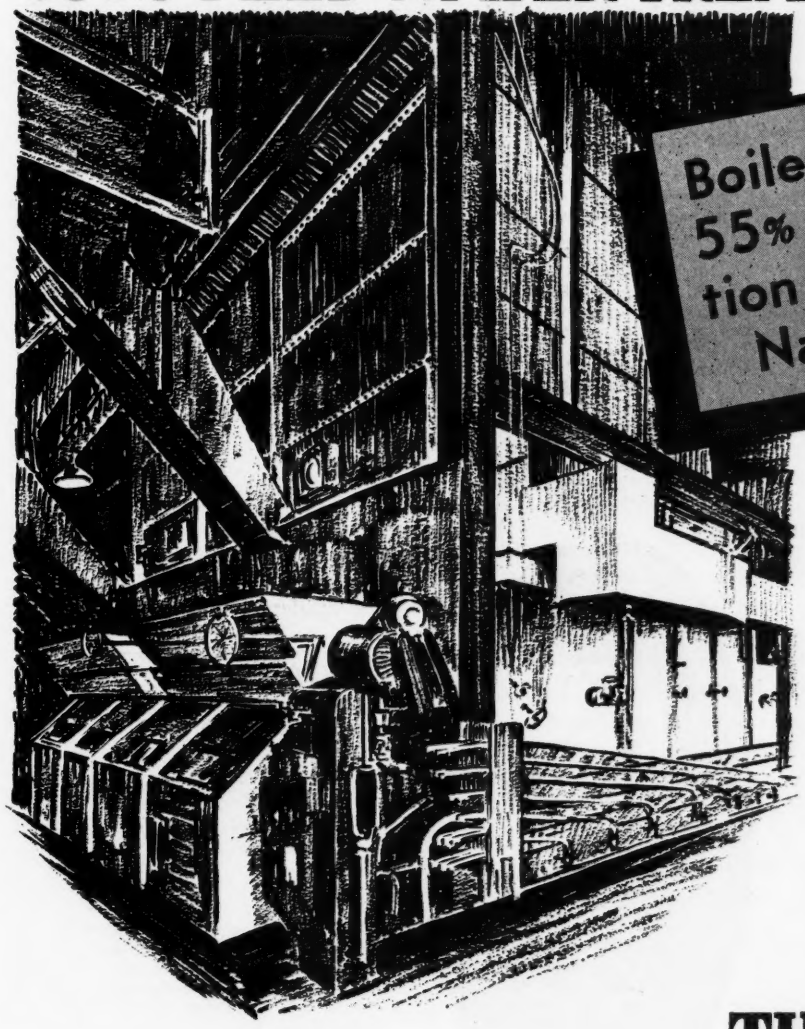
that each side is provided with a low pressure and a high pressure cylinder in tandem. Automatic regulation in five steps is provided by unloading or holding open the inlet valve. High and low pressure cylinders on each side are mounted on a cast iron base to insure alinement of the cylinders and to facilitate installation.

The second new machine is a horizontal duplex dry vacuum pump available in either single or two-stage design.



With the exception of the vacuum cylinder the design of this vacuum pump is the same as the single-stage compressor described in Bulletin 726 and Bulletin 724. The cylinders have valves arranged parallel to the piston face so as to minimize clearance losses; have automatic water relief and drain valve in each cylinder head and a hand-operated relief valve for starting. These pumps are available for flat belt, V-belt, direct boiler connection or steam drive.

CUTS FEEDWATER TREATING COSTS



Boiler Plant Gets 55% Cost Reduction by using the Nalco System

PRIOR to introduction of the Nalco System, a medium size plant in the northwestern part of the country was spending an average of $2628.00 every 365 days for chemicals to treat fairly soft water. This, probably, would never have caused any comment if the results had been satisfactory. Therefore, when the Nalco System eliminated complaint, it was doubly satisfying to find its cost averaging only $1168.00 for a year of 365 days—a saving of 55%.

When one of the boilers in this plant was opened up recently, the engineer reported it: "Cleaner than when new!"

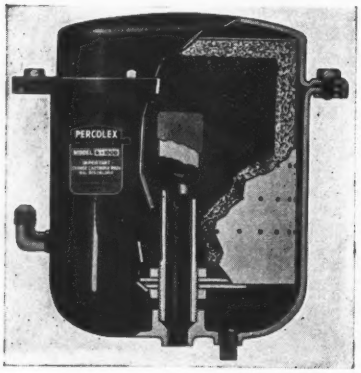
AS every engineer knows, cost of chemicals is a secondary matter as compared with the results secured when it comes to treating boiler feedwater. Nevertheless, it is significant to know that the complete cost of using the Nalco System is seldom more and is often less than for treating methods previously used. Let us make a survey of your requirements. No obligation. NATIONAL ALUMINATE CORPORATION, 6224 W. 66th Place, Chicago, Ill.

THE NALCO SYSTEM OF FEEDWATER TREATMENT

Inquiries other than domestic, *except those from U. S. Possessions, Canada and Mexico,* should be addressed to Alfloc Ltd., Bush House, Aldwych, London, W.C. 2, Eng. Canadian inquiries should be sent to Aluminate Chemicals Ltd., 372 Bay St., Toronto, Ont.

Oil Filter

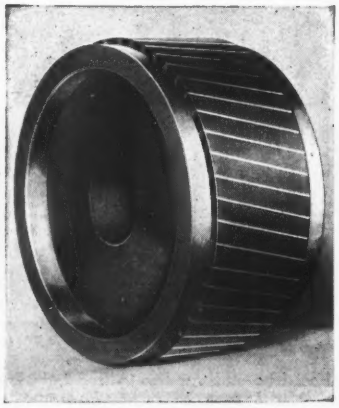
A NEW, complete line of Oil Filters, under the name Percolex, The Perfect Clarifier, is announced by The Dushane Co., Inc., 1516 So. Wabash Ave., Chicago, Ill. With this new filter the oil must pass through six distinct filtering agents, illustrated in the accompanying cutaway photograph. These are, 1—The perforations in the removable cartridge



shell; 2—highly compressed waste that absorbs dust, dirt and sludge; 3—special "earths" similar to those used by refineries to absorb water and acids; 4—a protective as well as filtering product; 5—a fabric filtering agent that stops abrasives; 6—a fine mesh metal screen. The dust, dirt and sludge removed from the oil by Percolex become trapped in a sump below the cartridge. Models for all types of internal combustion engines, whether gas, gasoline or Diesel are available.

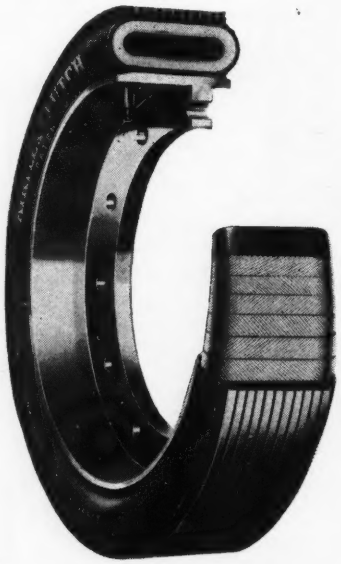
Copperspun Rotor

FAIRBANKS, MORSE & Co., Chicago, Ill., announces a new one-piece centrifugally cast Copperspun Rotor having high mechanical strength and the ability to withstand high temperatures. The new rotor winding is manufactured of pure copper. The rotor bars and end rings are formed in one piece by pouring molten copper into a mold that encases the punched laminations, stacked and held under pressure. Copper is poured from one end only as the entire assembly is spun at high speed. The opposite end ring is formed by material that has passed through the rotor slots insuring a fluid material during the casting process. As a result of the centrifugal force, a tough, dense, ductile copper winding is produced with high strength, full slots and uniform structure and conductivity. After completion of the centrifugal casting of the one-piece copper winding, the rotor is machine finished over all surfaces. This gives a true running rotor.



Rubber Clutch

THE SAME engineering principle used to prevent motor-cars from skidding on wet and slippery pavements is used in a new type of mechanical clutch. When the multi-vaned tread of the General Dual-10 and Dual-8 motor-car tires was perfected by General Tire & Rubber Co. engineers, it was proved that, under braking pressure, the many narrow vanes or ribs of rubber squirmed into a serpentine form and clung to the road surface with a high degree of adhesion. Adhesion being the principal job of a clutch, it was only a step from the multi-vaned tire to the Airflex rubber clutch, whose multi-vaned surface clings to steel with twice the friction coefficient of asbestos or other conventional clutch lining.



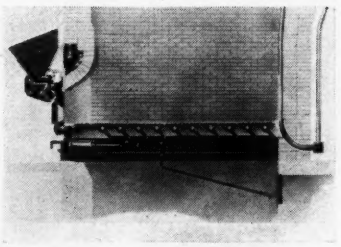
The Airflex rubber clutch is light, simple, having only three or four parts and is self-adjusting. The 40-in. Airflex clutch, the largest made up to this time, is being used on marine engine applications and has a 3000 hp. capacity. A complete line of Airflex clutches is being developed for industrial purposes, such as machine tools, conveyors, Diesel electric generators, and similar uses, as well as the larger applications in the marine engine and oil well fields.

Two distinct types of lining are used, on both the expanding and constricting types of Airflex clutches. When excessive slippage is encountered and where loads are to be picked up gradually, the use of friction lining is recommended. When the plain rubber squeegee-tread is used, a reasonable amount of slippage can be tolerated if the engagements are not too frequent. The clutches are given special treatment to prevent disintegration by oil fumes. A special rotary seal has been developed to deliver air to the clutch, either by entering the shaft at the end or by a straddle-type seal.

The Fawick General Co., Akron, Ohio, has been organized to manufacture the new Airflex clutch and will be affiliated with The General Tire & Rubber Co. Thomas L. Fawick, of Akron, Ohio, the inventor of the Airflex clutch, is prominently identified with the company. Licenses for the distribution of the Airflex marine type clutch have been granted to the Falk Corp. of Milwaukee, Wis.

Howell Stoker Acquired By Continental

THE INDUSTRIAL Equipment Division of the Continental Roll & Steel Foundry Co., East Chicago, Ind., has acquired the Howell Engineering Co., St. Charles, Ill., and will hereafter manufacture the Howell Stokers made under the B. F. Bower patents and patents pending. Continental stokers, grates and accessory equipment will be manufactured at the company's East Chicago plant exclusively and will be sold under the name Continental Spreader Stokers for 100 to 2000 hp. boilers. They are overfeed type and burn solid fuel in suspension over the entire grate area. They provide thorough combustion regardless of grade or moisture content of fuel.



B. F. Bower, formerly with the Howell Engineering Co., and the designer of the Continental Spreader Stoker, is now affiliated with Continental as Chief Engineer of the Industrial Equipment Division. The L. A. Snider Engineering Service, Chicago, distributors of Howell Stokers has been taken over by Continental and will function as the Chicago Sales Office for Continental Spreader Stokers under the direction of A. F. Ericksen at 605 N. Michigan Ave., Chicago.

Hose

HEWITT RUBBER CORP., Buffalo, N. Y., announces the following new products and product changes: Added to meet a demand is Ajax Tank Car and Tank Truck Unloading Hose, which is designed for the discharging or handling of gasoline under moderate suction only. Hewitt's Maltese Cross Hewprene Gasoline Hose is now furnished with a non-discoloring Neoprene tube in all sizes, 1¼ to 3 in. Another addition to the Hewitt line is Conservo Red Covered Air Hose.

THE COMPLETE LUNKENHEIMER LINE

Immediately Available

From Distributors Conveniently Located to Serve You

VALVES

Bronze, Iron, Steel and Corrosion-Resistant Alloy; Globe, Angle, Cross, Check, Gate, Throttle, Non-return, Blow-off, Pop Safety, Relief, Whistle, etc.

OIL AND GREASE CUPS

Glass, Bronze or Aluminum Body Oil Cups; Bottle Oilers; Constant Level Oil Controls; "Glaswick" Oil Cups; Automatic or Screw Feed Bronze Grease Cups.

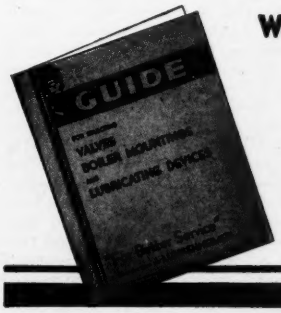
BOILER MOUNTINGS

Non - return, Pop Safety and Blow - off Valves; Water Columns, Water Gauges and Gauge Cocks; Fusible Plugs.

LUBRICATORS

For Steam, Gas, Gasoline, Oil Compressor and Pump Cylinders; Gravity Feed or Hydrostatic.

Whistles, Cocks, Fittings, Unions, Air Nozzles, Etc.



The Guide is a ready reference for selecting Valves, Boiler Mountings and Lubricating Devices in which products are grouped by pressure, type and use. List Price Schedule R1 gives new list prices of Lunkenheimer Products. Ask your local Lunkenheimer distributor for copies or write us direct.

ESTABLISHED 1862

THE LUNKENHEIMER CO.

"QUALITY"

CINCINNATI, OHIO, U. S. A.

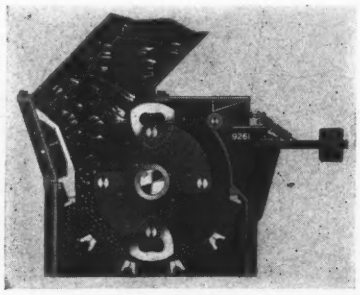
NEW YORK CHICAGO
BOSTON PHILADELPHIA

EXPORT DEPT. 316-322 HUDSON ST. NEW YORK

28-55B-44

Ring Type Crusher

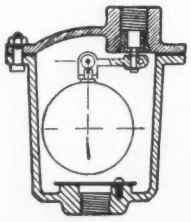
STEPHENS-ADAMSON MFG. CO. announces the new Ring Type Crusher. Triangular shaped manganese steel sectors operate so as to crack lumps rather than crush them which minimizes pulverizing to reduce the volume of fines. The new line is already being marketed in sizes to handle lumps of all types of bulk materials ranging in size from 6 in. to 26



in. The combined improvements of the new triangular sector and the use of only two gangs of sectors on the rotor, permit handling of larger lumps in a given size machine than was formerly possible. The centrifugal action of the sectors automatically presents the least worn surface of this triangular manganese steel part for crushing duty. Any unit in this new line of crushers can be furnished with or without apron fingers to eliminate automatically tramp iron or other foreign materials.

Air Release Valve

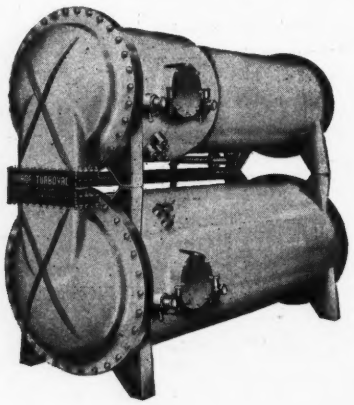
A NEW LINE of Air Release Valves which automatically rid pipe lines and other closed vessels of entrained air or any other gas is announced by the V. D. Anderson Co., Cleveland, Ohio. Three different styles of air release valves are included. First, the standard Silvertop is made in six sizes from ½ in. to 2 in. inclusive for pressures up to 250 lb. per sq. in. Second, the forged steel Silvertop for use on high pressures up to 1000 lb. per sq. in. These are made in three sizes with pipe connections of ½, ¾, 1, 1¼, 1½ and 2 in. Third, the Anderson No. "0," the original air release valve, is made in the ¾ in. size only for a maximum pressure of 150 lb. per sq. in.



As shown in the accompanying drawing, the Anderson Air Release Valve consists of a valve and seat, a lever and a ball float inside of a case. The inlet is at the bottom and the air vent is at the top. The liquid raises the float, and holds the valve closed. An accumulation of air or gas lowers the liquid level, causing the float to drop. This opens the valve and vents the air of gas. In operation Anderson Air Release Valves are placed at the high points in the pipe line where the accumulations of air are automatically vented, eliminating air-binding.

Turbovac

THE TRANE TURBOVAC a hermetically sealed low pressure water chiller is announced by The Trane Co., La Crosse, Wis. Within a heavy steel casing it contains a compressor of the centrifugal type, using a volatile refrigerant of the Freon family, a water chilling unit and a condenser. All the necessary parts of this new water chiller are combined in one complete compact unit.



Because it is practically impossible to build a unit of this type with leak-proof joints when the source of power is on the outside of the unit, Trane engineerrs have designed the Turbovac Water Chiller with the motors inside the unit and with the entire unit hermetically sealed. Motors are oiled from the outside of the unit when it is in operation. The shells are electrically welded of heavy steel plates and all joints are sealed with neoprene gasket material.

At present the unit is available in one size with capacity ranges from 65 to 80 t. At a very early date, units of 100, 150 and 200-ton capacities will be added. The unit itself is approximately 11½ ft. long, 8 ft. high and 4 ft. wide. It weighs slightly more than 12,000 lb.

Hand Pump

A COMPACT, portable hand pump for testing Diesel fuel injectors of all standard makes is now being made by Diesel Equipment Co., 4401 N. Ravenswood Ave., Chicago, Ill. It is designed to permit the user to check all size injectors.

The compactness of the Deco hand pump makes it especially handy for use in the field of engine dealers' service men, fleet operators and laboratory engineers. It stands only 9 in. high. The pump proper weighs but 6 lb., the detachable handle 2 lb. It fits easily into service kits or tractor and tool boxes. It can be used any place there is room for setting the base, 4¾x2½ in. Because it is so small and light, it can be carried to the top of big Diesel engine plants and used in cramped spaces where testing with large outfits would be impractical. When used in laboratories, the pump can be bolted down—three holes are provided in the base for that purpose.

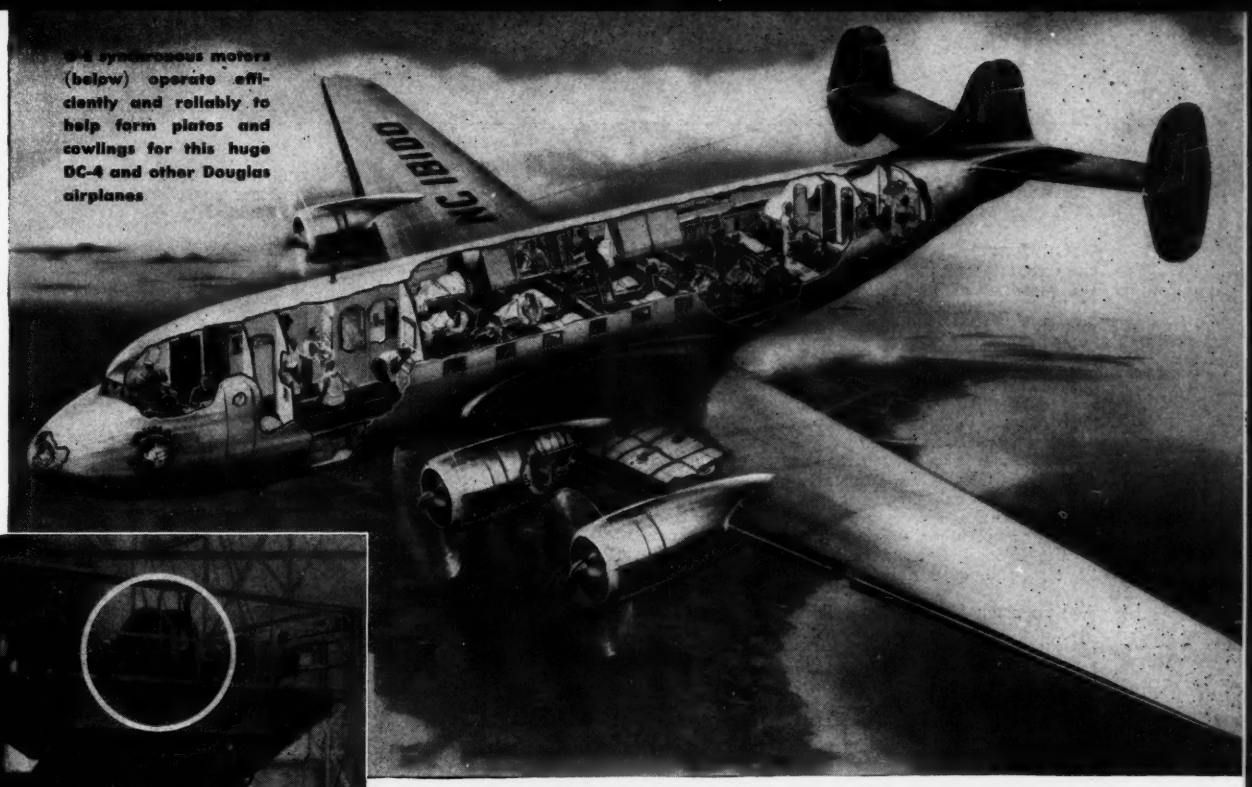
pH Recording and Controlling Instruments

A NEW line of pH Recorders and Controllers has just been announced by The Bristol Co., Waterbury, Conn. These instruments employ the glass electrode method of measurement and are designed especially for industrial plant use. They are offered in two general types: wide strip-chart model and the round-chart model. Automatic controllers are offered in both electric and air-operated models.

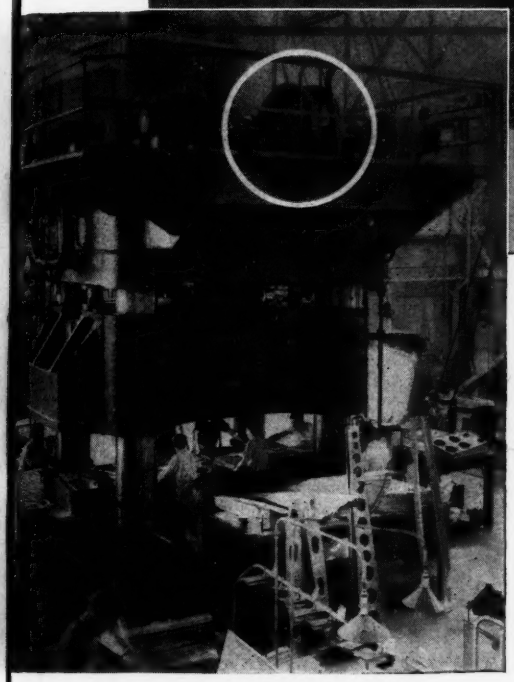
Shielded glass and Calomel Electrodes are used for measurement and control. The shielded glass electrode is completely sealed and internally shielded from electrostatic interference. The companion calomel electrode has a factory-filled internal assembly, immersed in a saturated potassium chloride solution contained in the outer tube of the electrode. Electrolytic connection between the internal assembly and the solution under measurement is maintained through a small hole protected by a ground glass sleeve.

New Alloy Steel

THE BABCOCK & WILCOX TUBE CO., Beaver Falls, Pa., announces the development of Croloy 7, a new alloy steel for elevated temperature service in tubular form. This new alloy is a result of the metallurgical research program that The Babcock & Wilcox Tube Co. has been conducting for some years past in an effort to develop new alloys for high-temperature and high-pressure service. It was this program which was largely responsible for the development of many of the alloy steels in present day use in tube form. These include notably: 5 per cent chromium steel with molybdenum addition; 2 per cent chromium-0.50 per cent molybdenum steel; 9 per cent chromium-1.25 per cent molybdenum steel; and the further modification of the 2 per cent chromium-0.50 per cent molybdenum type steel by the addition of a higher percentage of molybdenum to obtain increased creep strength and now called Croloy 2¼.



G-E synchronous motors (below) operate efficiently and reliably to help form plates and cowlings for this huge DC-4 and other Douglas airplanes

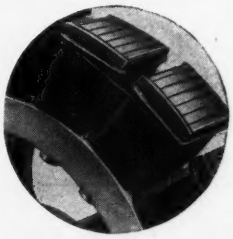


How TWO G-E SYNCHRONOUS MOTORS Helped Build This Hotel-on-Wings

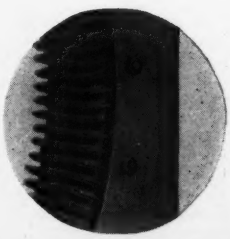
IN ONE of the world's largest aircraft plants—that of the Douglas Aircraft Company of Santa Monica, California—two G-E synchronous motors drive pumps for operating the giant hydraulic press that fabricates plates, cowlings, and other parts for all Douglas airplanes, including this huge DC-4. The two motors have been in operation for more than two years and have proved themselves to be reliable and efficient pump drives. In addition, the Douglas Company has earned approximately $1000 a year in bonuses due to the power-factor improvement made possible by these two motors.

Synchronous motors are the most efficient and reliable drives for many constant-speed applications, such as certain types of compressors and pumps. Their inherent ability to improve power-factor means lower energy charges, lower demand charges, and often, lower power rates. In addition, they assure better operation of all other electric equipment because of improved voltage regulation. The efficiency of the entire distribution system is increased because line losses are minimized.

Why not investigate the possibility of making savings in your own plant through the use of synchronous motors? G-E application engineers will be glad to help you. Call the nearest G-E office, or write General Electric, Schenectady, N. Y.



n G-E synchronous motors the bars f the amortisseur winding are fitted nto holes in the heavy, sectionalzed, copper end-rings and are ilver-soldered at red heat to form ow-resistance, brazed alloy joints of igh mechanical strength. This arangement permits easy removal of ne or more field poles without disurbing the remaining poles



Low core loss is assured by laminaions of best-grade, nonaging, silicon heet steel, carefully annealed and namneled. Deep, radial I-bars, spotelded to the outside laminations, ssure a uniformly tight core and uiet operation

GENERAL ELECTRIC

040-54

News from the Field

ON JULY 1, 1939, Leroy M. Glodell, chief engineer of the Biltmore Hotel in Los Angeles, Cal., died of a heart ailment. He had held his position since the hotel was opened 15 yr. ago. His successor as chief engineer of the hotel is Van E. Gee, who has been assistant engineer during all these years.

FEDERAL POWER COMMISSION announces the election of Acting Chairman Clyde L. Seavey as Chairman, and Commissioner. Claude L. Draper as Vice Chairman. Leland Olds, for a number of years executive secretary of the New York Power Authority, is now a member of the Federal Power Commission for the term ending June, 1944.

EXCLUSIVE United States license for the manufacture and sale of Fast's multiple oil film bearings has been acquired by Koppers Company. These bearings will be produced by the company's Bartlett Hayward Division. These bearings will become a companion product to the Fast's self-aligning coupling which the organization has been manufacturing for many years. Manufacturing rights and facilities have been obtained from The Fast Bearing Co.

THE GENERAL ELECTRIC VAPOR LAMP Co. has been merged with the Incandescent Lamp Department of General Electric Co. Because of this change, General Electric's activities in incandescent and electric discharge lamps are brought together and the Incandescent Lamp Department will hereafter be known as the Lamp Department of the General Electric Co.

DR. WILLIAM MCCLELLAN, president of American Engineering Council, has resigned as president of the Potomac Electric Power Company, Washington, D. C., to become the head of the Union Electric Company of Missouri, with headquarters in St. Louis. Both companies are subsidiaries of the North American Company.

NOMINATIONS for Officers of The American Society of Mechanical Engineers for 1940 were announced at a recent meeting of the national Nominating Committee held at State College, Pa. Election will be held by letter ballot of the entire membership, closing on September 26, 1939. The nominees as presented by the Regular Nominating Committee of the Society are: President, Warren H. McBryde, Consulting Engineer, San Francisco, Calif.; Vice-Presidents, Kenneth H. Condit, Ex. Asst. to president National Industrial Conference Board, New York, N. Y., Francis Hodgkinson, Consulting M. E., New York, N. Y., J. C. Hunsaker, Head of Dept. of M. E., Mass. Inst. of Technology, Cambridge, Mass., K. M. Irwin, Asst. to V. P., Charge of Engineering, Philadelphia Electric Co., Philadelphia, Pa.; Managers, J. W. Eshelman, President, Eshelman & Potter, Birmingham, Ala., Linn Helander, Head of M. E. Dept., Kansas State College, Manhattan, Kansas, G. T. Shoemaker, President, The United Light & Power Service Co., Chicago, Ill.

AMERICAN ENGINEERING Co., Philadelphia, announces the appointment of A. C. Cooper Sales Co., 220 E. 42nd St., New York city, as sales representatives for metropolitan New York, Long Island, and Northern New Jersey. A. C. Cooper Sales Co. specializes in the selling of materials handling equipment. Julian Florandin is now associated with the company.

THE LINCOLN Electric Railway Sales Co., Cleveland, Ohio, announces the appointment of Thomas V. Brooke, a graduate of Virginia Military Institute and for several years associated with Lincoln Electric Co. as a research engineer, as sales engineer with its Chicago office, 310 South Michigan Ave.

PROFESSOR Alexander Graham Christie, of the Johns Hopkins University, Baltimore, Md., and President of the American Society of Mechanical Engineers, had the honorary degree of Doctor of Engineering bestowed upon him on June 10 by Stevens Institute, Hoboken, N. J., in recognition of his creative work in steam power production and use.

ARNOLD E. WEICHERT, for the past 24 years with Combustion Engineering Company, Inc., in engineering, estimating and sales work, died suddenly on July 2 at his home in Bloomfield, N. J.

WILFRED R. WOOD, director, member of the Executive Committee and consultant to the President of Combustion Engineering Company, died at Doctors Hospital, New York, on July 14, at the age of 69.

Born in Virginia, Mr. Wood's early engineering experiences was with the Fishkill Landing Machine Works and with Russell & Co. of Massillon, Ohio, makers of high-speed engines and road rollers and later with the Stoddard Mfg. Co. and the American Stoker Co. His patent, granted in 1898, was the first to employ a screw feed running in a stoker retort.

In the following year Mr. Wood went to England and formed the Underfeed Stoker Co., a British concern of which he became the managing director. He designed a self-cleaning underfeed stoker, the Type E, and was instrumental in developing the plate-type air preheater. During his stay in England he became associated with the predecessor of Combustion Engineering Co. as senior vice president. He returned to this country in 1929 and was identified with this company until the time of his death.

THE CENTRAL topic of the Third Annual Joint Meeting of the Fuels Division of the American Society of Mechanical Engineers and the Coal Division of the American Institute of Mining and Metallurgical Engineers to be held at the Deshler-Wallick Hotel, Columbus, Ohio, October 5, 6, and 7 will be coal utilization. H. O. Croft, State University of Iowa, H. F. Hebley, Commercial Testing and Engineering Company, H. E. Nold, Ohio State University, J. E. Tobey, Appalachian Coals, Inc., and R. A. Sherman, Battelle Memorial Institute, chairman, compose the program committee.

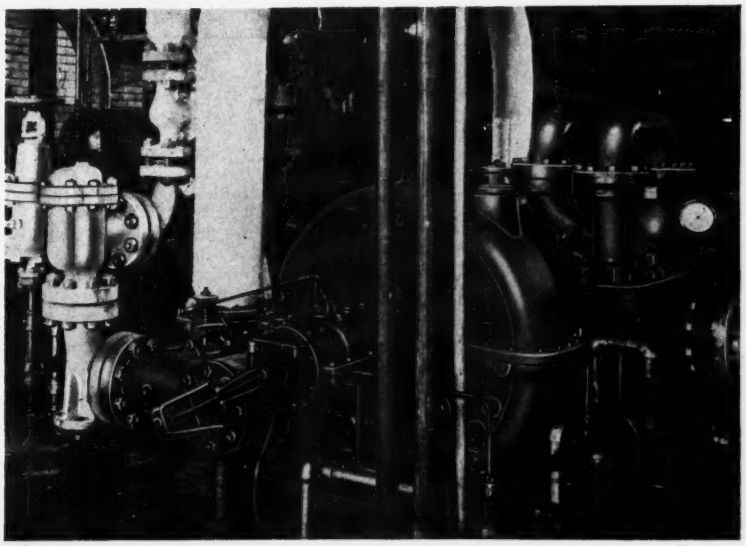
THE FOLLOWING officers were elected at the 33rd Annual Convention of the Smoke Prevention Association, at Milwaukee, Wisconsin, for the year 1939-1940; Reinhard W. Kunz, President, Chief Smoke Inspector, Dept. of Safety, Milwaukee, Wis.; George G. Richie, First Vice President, Fuel Service Engineer, Chesapeake and Ohio Ry, Co., Richmond, Va.; John Benschip, Second Vice President, Smoke Inspector, Pennsylvania Railroad, Chicago, Ill.; F. A. Chambers, Secretary-Treasurer, Chief Smoke Inspector, Chicago, Ill.; Leo B. Miller, Sergeant-at-Arms, Illinois Northern Ry., Chicago, Ill.

Following the election, St. Louis, Missouri, was chosen as the Convention City for June, 1940.

New Office Building

THE V. D. ANDERSON Co. of Cleveland, Ohio, was moved into the spacious new two-story office building shown here. This new building, fronting on West 96th Street, is of fireproof construction and is completely equipped with new furniture and the latest office equipment. The opening of this new Anderson office building marks the completion of 59 years of continuous manufacturing. The company was founded in 1880 and was incorporated as The V. D. Anderson Company in 1888.

TERRY



RCA's 900 LB. PLANT DEPENDS ON TERRY SOLID WHEEL TURBINES FOR FEED PUMP DRIVE

Pictured above is one of two 294 HP Terry Wheel Turbines installed in the new superposed plant of the R. C. A. Manufacturing Co. in Camden, N. J. These turbines operate with steam at 850 lbs., 750° T. T., and drive boiler feed pumps at 3550 RPM — a vital and important service which they are performing efficiently.

The turbines employ the solid one-piece Terry wheel. The buckets are milled directly into the rotor so that there are no parts to work loose. The clearances are generous and the blades are double rim protected. Such design assures both reliable and economical operation.

The Terry wheel turbine is fully described in our bulletin S-116. A request on your business letterhead will bring a copy.

T-1132

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD, CONN.

C. MAXWELL STANLEY and Arthur E. Stanley announce the organization of a firm under the name of Stanley Engineering Co. The new firm has acquired the practice of Young & Stanley, Inc., Engineers, of Muscatine, Iowa, and will continue to engage in the general practice of engineering.

THE DIAMOND MACHINE CO., Providence, R. I., has been purchased by the American Engineering Co. who will continue the manufacture of the Diamond Face Grinder in its Philadelphia plants.

IRON FIREMAN MFG. CO. announces four new regional representatives, namely: J. Warren, Daniels, eastern division district representative; Gary Baker, eastern representative of the heating equipment division; C. W. Robinson, eastern division district salesman, and Stanley Glenn, eastern division district salesman.

CUTLER-HAMMER, INC., Milwaukee, announces the appointment of E. W. Seeger as Manager of the Development Department and P. B. Harwood as Manager of Engineering Department for the Company. B. M. Horter has been appointed General Sales Manager of the company.

RICHARD P. BROWN, former President and now Chairman of the board of the Brown Instrument Co. and Vice-President of Minneapolis-Honeywell Regulator Co., has been appointed by Governnr Arthur H. James to be the first Secretary of the new Department of Commerce of the Commonwealth of Pennsylvania.

Electrical Engineers Elect Officers

F. MALCOLM FARMER, vice-president and Chief Engineer, Electrical Testing Laboratories, New York, N. Y., was elected President of the American Institute of Electrical Engineers for the year beginning August 1, 1939, as announced at the annual meeting of the Institute held in San Francisco, Calif., during the combined annual summer and Pacific Coast convention of the Institute. The other officers elected were: Vice-Presidents C. T. Sinclair, Pittsburgh, Pa.; E. E. George, Chattanooga, Tenn.; Albert L. Turner, Omaha, Neb.; H. W. Hitchcock, Los Angeles, Calif.; J. M. Thomson, Toronto, Ontario, Canada.—Directors Mark Eldredge, Memphis, Tenn.; R. E. Hellmund, East Pittsburgh, Pa.; Frank J. Meyer, Oklahoma City, Okla.—National Treasurer W. I. Slichter, New York, N. Y. (re-elected).

These officers together with the following hold-over officers will constitute the Board of Directors for the next administrative year, beginning August 1, 1939: John C. Parker (retiring President), New York, N. Y.; C. R. Beardsley, New York, N. Y.; F. C. Bolton, College Station, Tex.; Vannevar Bush, Washington, D. C.; C. L. Dawes, Cambridge, Mass.; L. R. Gamble, Spokane, Wash.; W. H. Harrison, New York, N. Y.; F. H. Lane, Chicago, Ill.; A. H. Lovell, Ann Arbor, Mich.; L. R. Manes, Chicago, Ill.; K. B. McEachron, Pittsfield, Mass.; H. S. Osborne, New York, N. Y.; C. A. Powel, East Pittsburgh, Pa.; D. C. Prince, Philadelphia, Pa.; R. W. Sorenson, Pasadena, Calif.

For the Engineer's Library

Recent bulletins and catalogs on power plant equipment listed for your convenience in securing specific information. Power Plant Engineering will be glad to procure for you any free literature that you desire.

Metals

Metal—Antimonial Admiralty, the latest development in condenser tube alloys is illustrated and described in a new booklet. Chase Brass & Copper Co.

Metal—A new folder containing basic information on mechanical, corrosion-resistant and other properties of rolled nickel, Monel, and other high nickel alloys has just been issued by The International Nickel Co.

Ward Sheet Metal Working Machinery is describedt in 64-page Catalog 39. Machines, Tools and supplies for fabricating sheet metal are illustrated. Ward Machinery Co.

Specifications for Seamless Tubular Products is the title of Technical Bulletin 11-B. The bulletin contains specifications established for carbon steel and alloy steel tubes by the American Society for Testing Materials and The Association of American Railways, and specifications established by The Babcock & Wilcox Tube Co. for high chrome and stainless alloy tubes. The Babcock & Wilcox Tube Co.

Steel—Catalog 59 portrays the developments in research and improvements in production facilities and organization that have contributed to establish Amsco Manganese Steel throughout industry. Containing 60 pages the catalog is the most complete presentation of the subject that has ever been made. American Manganese Steel Div. of The American Brake Shoe & Foundry Co.

Water Conditioning

Modern Preparation of Water for Ice Making—An eight page, non-technical booklet, No. 2205, under this title shows how impurities cause trouble in ice making and how the impurities can be removed by use of proper equipment. The Permutit Co.

Refrigeration — Bulletin S-500-B37 illustrates and describes Worthington evaporation coolers for engine jacket water for use with stationary type Diesel and gas engines. The Carbondale combined unit air conditioner is illustrated and described in Catalog C-1100-B3. Worthington Pump and Machinery Corp.

Pressure Filters—Bulletin 2225 illustrates and describes the deflector plate distributor features in Permutit Type "F" filters. Information on the new Expansible Strainer Heads and Group Control of filter units is also included in the Bulletin. The Permutit Co.

Feedwater Heaters — Worthington deaerating heaters and deaerators of the vertical double-element type are described in a new bulletin W-210-B24. The Worthington Pump & Machinery Corp.

Automatic De-Sludging Valve for hot lime soda softeners is described in Bulletin 2218. It is a motor operated disc type valve which de-sludges the softener in frequent short blowdowns thus saving heat and maintaining sludge concentration in softener between optimum working limits. The bulletin contains 2 pages and gives specifications. The Permutit Co.

Instruments, Meters and Controls

Instrument—A new bulletin No. 157 on the Model "JP" Ground-Onmers modified for geophysical tests and investigations, permitting the instrument to be used not only for measurement of the resistance of ground connections but also for the measurement of soil resistances. Herman H. Sticht & Co.

Controls—Bulletin 680-1 illustrates and describes the Wheelco Rheotrol giving description, operation, special features and specification. The Wheelco Modulating Gas Valve is the subject of Bulletin 1224-1 giving the operation, applications and specifications. Wheelco Instruments Co.

Pyrometers and Resistance Thermometers—A 4-page folder, Bulletin 773, under this title contains brief descriptions of several of the most familiar instruments in the Foxboro line of pyrometers. Instruments described include: the Potentiometer indicating recording controller, the potentiometer recording pyrometer, potentiometer controllers for electric or air-operated control, the Stabilog potentiometer controller, the potentiometer indicating pyrometer, the mono-pivot type indicating pyrometer, the portable indicating potentiometer and the key switch cabinet indicating potentiometer. The Foxboro Co.

Instruments — This bulletin illustrates and describes the portable CO_2 Indicators and Draft Gages. Interesting charts showing fuel losses in coal and oil fired heating plants are shown and temperatures for most efficient operation are given. F. W. Dwyer Mfg. Co.

Weston Clamp-Ammeter—A 4-page illustrated folder A-2-B completely describes this new portable ammeter, placing particular stress on ease of use, accuracy and safety. Weston Electrical Instrument Corp.

Always get Reading-Pratt & Cady Valve recommendations

CAST STEEL VALVES FROM READING . . .

Cast Steel Valves and Fittings are made in the Reading, Pennsylvania plant where pressure steel castings were pioneered and developed for use in Cast Steel Valves. In this plant is centered a highly specialized organization concentrated upon production to meet the service asked of Cast Steel Valves today.

READING-PRATT & CADY recommendations for Cast Steel Valves for your steam power plant today are based on the solid foundation of Reading Steel Company's pioneering of pressure castings and their development of Cast Steel Valves . . . Years have but added to this experience.

•

For example, there was the alliance with Pratt & Cady at Hartford, Connecticut that opened to the Cast Steel men of Reading a wealth of valve engineering data and research facilities of practical value in today's READING-PRATT & CADY Cast Steel Valves.

•

Later, there was the development of a group of metallurgists—and engineers—organized to keep Reading Cast Steel Valves in time with changing industry and help meet the demand on your plant for lower production costs.

•

Every step in the life of this Cast Steel Valve organization has made it of greater service to you today. Make it a point, always, to get their recommendations.

BRONZE AND IRON VALVES FROM HARTFORD . . .

From the men and plant in Hartford—where we concentrate on Bronze and Iron valves—have come such original developments as Check Valves, Bar Stock Valves and Asbestos Packed Cocks. They, too, are responsible for many of the improvements in Bronze and Iron Valves that have broadened the service given by modern Globe valves and Gate valves.

R P&C

READING-PRATT & CADY

READING-PRATT & CADY DIVISION · BRIDGEPORT · CONNECTICUT

See our exhibit, Metals Building, New York World's Fair

AMERICAN CHAIN & CABLE COMPANY, Inc.

AMERICAN CHAIN DIVISION • AMERICAN CABLE DIVISION • ANDREW C. CAMPBELL DIVISION • FORD CHAIN BLOCK DIVISION • HAZARD WIRE ROPE DIVISION • HIGHLAND IRON AND STEEL DIVISION • MANLEY MANUFACTURING DIVISION • OWEN SILENT SPRING COMPANY, INC. • PAGE STEEL AND WIRE DIVISION • READING-PRATT & CADY DIVISION • READING STEEL CASTING DIVISION • WRIGHT MANUFACTURING DIVISION • IN CANADA: DOMINION CHAIN COMPANY, LTD. • IN ENGLAND: BRITISH WIRE PRODUCTS, LTD. • THE PARSONS CHAIN COMPANY LTD. • *In Business for Your Safety*

Inclined Draft Gages is the title of Bulletin 9-C. The equipment is fully described and tables and directions on how to use a pitot tube are given. Ellison Draft Gage Co.

Strainer—A new 4-page bulletin illustrates and describes the Brassert automatic strainer, giving construction, operation and specifications. H. A. Brassert Co.

Megohmer—A new bulletin No. 173 illustrating and describing the Model DM Megohmer with the triple color grading scale has been issued by Herman H. Sticht & Co.

Electrical Equipment

Radio Transmitter Capacitor — A new 36 page Catalog No. 160-T illustrates and describes all the latest types of capacitors designed for use in the broadcast and industrial fields. Listings are concisely tabulated for simplified reading. Thirteen different capacitor types are listed. The last four pages of the catalog are devoted to technical information, curves, and instructions. Cornell-Dubilier Electric Corp.

Electrical Equipment—Three new bulletins describing various types of electrical equipment have just been issued. Type MLT-16/32 Step Voltage Regulators are described in Bulletin GEA-1577E. Bulletin GEA-137D gives a description of Type TS Low Speed Synchronous motors. Types Speed Synchronous generators, Types ATB and ATI are treated in Bulletin GEA-1960A General Electric Co.

Variac Transformers For Voltage Control is the subject of a new 4-page bulletin giving the important features, operating characteristics, sizes and specifications. General Radio Co.

Cable Fault Location—Catalog E-53-441 (1), a 6-page, thoroughly illustrated publication, shows the new design of Type U test set which has been improved for use of Hilborn loop. It is supplementary to the 52-page Note Book E-53-441 published last year, on up-to-date methods for cable testing and fault locating. Leeds & Northrup Co.

Generating Sets—Bulletin 108 containing 24 pages gives a complete description of Troy-Engberg Generating Sets of the vertical and horizontal type for either marine or stationary use. Following the general description is the engineering data for eight different models. Eight pages of the bulletin are devoted to detailed descriptions of the important parts that go to make up the generating set. Troy Engine & Machine Co.

Modern F H Breakers March on in Steel is the title of Catalog GEA-3143 dealing with two modern methods of solving the problems involved in station design and emphasizes the more important advantages of the FH cubicles. General Electric Co.

Pumps

De Laval Pumps at Buffalo is the title of an article by Howard W. Fitzgerald, Chief Engineer of the Division of Water, describing the Colonel Francis G. Ward Pumping Station at Buffalo, N. Y. It is being distributed by the De Laval Steam Turbine Co.

Pumps—Horizontal simplex direct-acting piston pumps are illustrated and described in Catalog W-111-B6C. Centrifugal Hot Charge Pumps for high pressure and high temperature are described in Catalog W-341-B6. Worthington Pump & Machinery Corp.

Submerged Suction Priming Equipment is the title of a leaflet in which automatic priming equipment for centrifugal pumps is described. De Laval Steam Turbine Co.

Coal Conveying and Preparation

Conveying Equipment — Vibrex Screens are illustrated and described in Bulletin 105, giving features, styles, construction and type installation views. Bulletin 106 describes the Robins Mead-Morrison Car and Barge Haulage Systems. The bulletin gives rope layouts, specifications and descriptions of the various equipment. Robins Conveying Belt Co.

Belting Biographies, a 36-page booklet describing the company's complete line of transmission and conveyor belts shows case histories dramatically illustrated, and contains much technical information, including data on the selection of the proper belt, installation, speed of operation, pulley size, tension, carrying capacity, etc., as well as numerous types of transmission drives and conveyor layouts, together with suggestions for improving belting methods. Mechanical Goods Division, United States Rubber Co.

Mosley Mill—This 12-page booklet contains dimensions, capacities and installation data on this new mill, in which dry materials pulverize themselves by attrition as a powerful current of air sweeps them around the grinding chamber. One section is devoted to the use of Mosley Mills for pulverizing and burning coal in small and medium size industrial boilers. Stephens-Adamson Mfg. Co.

Miscellaneous

Tools—Snap-on Wrenches and Blue-Point Mechanics' Tools are illustrated and described in the new 96-page catalog "N" which gives sizes, application, prices and special features. Snap-On Tools Corp.

Gears—Varied and numerous applications of worm gears in transmitting power to slow and moderate speed machinery of all kinds are illustrated in a publication entitled Worm Gears in Industry which is being distributed by the De Laval Steam Turbine Co., Trenton, N. J..

Cleaning — An interesting 48-page illustrated brochure, attractively bound, portraying the important part that production cleaning and its related operations play in America's leading industries, has just been issued by Oakite Products, Inc.

Air Eliminators — Bulletin 108 describes the high pressure air eliminator and automatic bypass giving construction specifications and prices. Gorton Heating Corp.

Furnace Refractories—The 1939 edition of a catalog under this title describes and illustrates the company's complete line of materials and designs including the Steel Mixture fire clay refractory, Carbex silicon-carbide non-clinkering super-refractory, SMA high alumina refractory, high temperature cements. McLeod & Henry Co., Inc.

Ventilator—This new folder covers the construction of the Monovent Continuous Ridge Ventilator. Several types of damper operators both manual and motor operated are shown and detailed methods of mounting and flashing the ventilator to all types of building construction included in the folder. The Burt Mfg. Co.

Mechanical Draft—Bulletin 3624, 32 pages in two colors contains illustrations and descriptions of complete fan equipment for all types of mechanical draft; the company's modern manufacturing methods and its facilities for research and development; and typical installation views. American Blower Corp.

HELPFUL BULLETINS

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WE'RE USING 25% MORE STEAM AND PAYING $321 LESS FOR FUEL

AN IRON FIREMAN "SPREADER" STOKER HAS CUT OUR FIRING LABOR COST 50%, TOO!

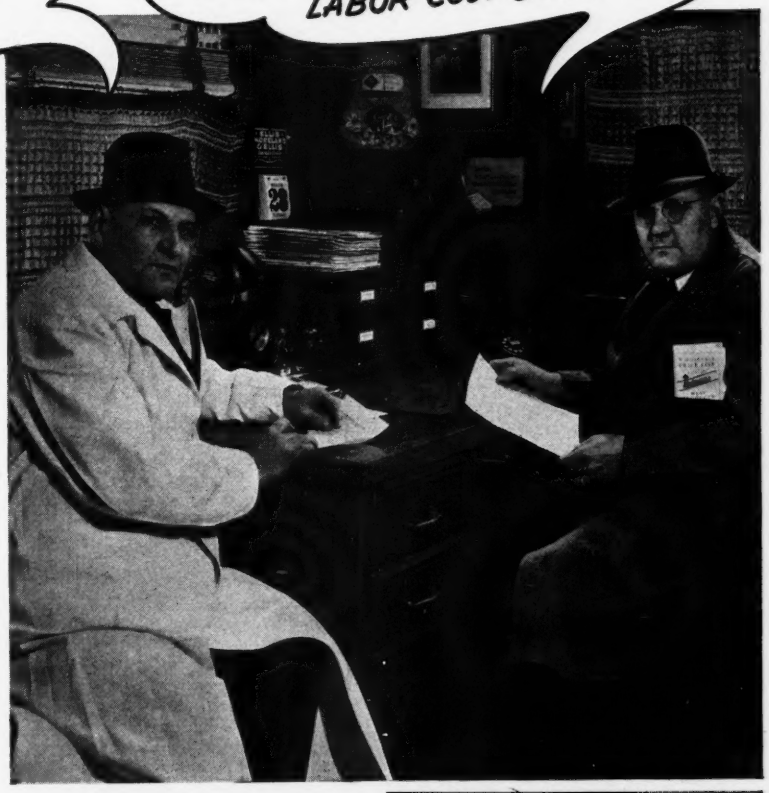
IRON FIREMAN

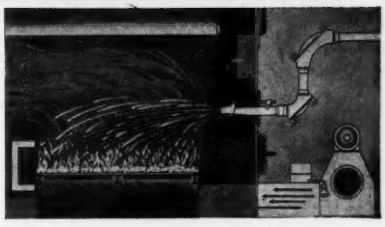
Industrial Stokers 2-to-1 Favorites

Here's the Kind of Performance that Put Iron Fireman on Top

SUPERIOR PERFORMANCE—that's the reason American industry's installations of Iron Fireman industrial stokers outnumber those of the next leading make by *more than 2-to-1.* Here is an example of this superior performance:

Before the Hofmann Packing Co. modernized its boiler room, its average annual fuel cost, for hand-fired coal, was $2121. Two and a half years ago Hofmann installed an Iron Fireman Pneumatic Spreader stoker. Since then, with a steady increase in business, steam consumption has jumped 25%. Yet the cost of fuel with Iron Fireman firing has averaged only $1800 a year—a cash saving of $321! At the same time, reports President A. C. Hofmann, labor in the boiler room has been reduced 50%, "and we do not have the wide variation in steam pressure that we formerly had with hand-firing."





Above: N. L. Hofmann, treasurer (left); and A. C. Hofmann, president. *Right:* The Iron Fireman Pneumatic Spreader—the type of stoker installed in the Hofmann plant. The coal is conveyed from hopper to boiler on a stream of high-velocity air. Fines burn in suspension; lumps burn in a shallow layer on the grates. The Iron Fireman Pneumatic Spreader is highly responsive—heavy withdrawals of process steam are quickly offset. In case of electric failure, the boiler may be hand-fired.

Our Offer to YOU: Give us the word, and we will make an engineering survey of your steam costs—without obligation to you. This survey will determine, on a conservative basis, what your fuel savings and betterments will be with Iron Fireman firing. *We will gladly work in cooperation with your own engineer, fireman or consulting engineer.* The experience of Iron Fireman in building and installing more industrial stokers than any other manufacturer is at your disposal. Telephone your local Iron Fireman representative, or send coupon.

Plant of the Hofmann Packing Company, Inc., Syracuse, N. Y., with delivery fleet in front.

This is the symbol of Iron Fireman—the machine that made coal an automatic fuel.

IRON FIREMAN

Automatic Coal Stoker

Iron Fireman Mfg. Co., Portland, Ore.; Cleveland; Toronto.
Mail to 3215 W. 106th Street, Cleveland, Ohio.

☐ Make a free engineering survey of our steam costs.

Send me: ☐ Industrial Catalog; ☐ Commercial Heating Catalog

Name _____

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Power Plant Construction News

Calif., Oakland—Bureau of Yards and Docks, Navy Department, Washington, D. C., has secured appropriation through Public Works bill for new naval supply depot at Oakland, to include a steam power house for central heating service, estimated to cost $200,000, with equipment; cold storage plant, $575,000, with machinery; and paint and oil storage building, $255,000, with tanks and equipment. Proposed to ask bids in near future.

Colo., Denver—Bureau of Reclamation, Denver, will receive bids until Aug. 15 for three 40,000-hp., vertical-shaft hydraulic turbines, and for three oil-pressure actuator-type governors for turbine units, for installation in Parker hydroelectric power plant, Parker Dam power project, Arizona-California. Equipment will be installed by Government (Specifications 867).

Del., Newport—Lincoln Fibre & Specialty Co., Newport, plans installation of electric power equipment in connection with proposed rebuilding of portion of fiber products manufacturing plant, recently destroyed by fire. Loss estimated about $50,000. John D. Taylor is head.

Ill., Elizabeth—Jo-Carroll Electric Cooperative, Inc., Elizabeth, M. S. Rogers, president, has plans maturing for new electric generating plant on local site for power supply for rural electric system. Cost about $75,000. Financing has been arranged through Federal aid.

Ind., Indianapolis—Indiana Farm Bureau Cooperative Association, Inc., 309 West Washington Street, Indianapolis, plans installation of electric power equipment in new commercial fertilizer plant at Belmont Avenue and State Road 67. A boiler house is proposed. Entire project will cost close to $150,000. Carlton, Frankenberger & Batson, 1816 Central Parkway, Cincinnati, Ohio, are consulting engineers.

Iowa, Denison—City Council is considering tentative plans for extensions and improvements in municipal electric power plant, including installation of additional equipment. Estimates of cost are being made.

Iowa, McGregor—Town Council has surveys and estimates of cost under way for new municipal electric power plant. Proposed to use Diesel engine-generator units and auxiliary equipment. Young & Stanley, Inc., Muscatine, Iowa, is consulting engineer. William R. Stone, Jr., is town clerk.

Kan., McPherson—City Council is arranging early call for bids for extensions and improvements in municipal power plant, to include installation of a new turbine unit and accessories, condenser, low-pressure heater, switchgear and auxiliary equipment. Cost estimated about $350,000. Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., is consulting engineer.

Kan., Topeka—John Morrell & Co., meat packers, plan installation of electric power equipment in new six-story and basement addition to local plant, for expansion in lard refining and other production divisions. Cost over $125,000. Work is scheduled to begin soon. Henschien, Everds & Crombie, 59 East Van Buren Street, Chicago, Ill., are architects and engineers. Main offices of company are at Ottumwa, Iowa.

Mass., Weymouth—Weymouth Art Leather Co., Weymouth, plans installation of electric power equipment in connection with rebuilding of portion of plant, recently destroyed by fire. Loss estimated close to $250,000.

Mich., Dearborn—Ford Motor Co., Dearborn, plans installation of power equipment in one-story addition, 300 by 680 ft., at River Rouge automobile works, to be used as a car delivery building, with testing, inspection and other mechanical departments. Entire structure will cost about $500,000. Work is scheduled to begin at once.

Mich., Holland—Chris-Craft Corporation, Algonac, Mich., plans installation of power equipment in new boat-building plant on waterfront at Holland, where tract of about 30 acres of land has been acquired. A power house is proposed. Entire project reported to cost over $85,000. Work is scheduled to begin soon.

Mich., Plainwell—Michigan Paper Co., manufacturer of book and other coated paper stocks, plans installation of electric power equipment in new addition to mill, to be used for expansion in coating division. Entire project will cost about $70,000. D. L Stocker is president and general manager.

N. J., Clifton—Curtiss-Wright Corporation, Propeller Division, 64 Lakeview Avenue, plans installation of electric power equipment in two new additions to aircraft propeller-manufacturing plant, 275 by 500 ft., and 90 by 100 ft. Entire project will cost close to $175,000. Work will be placed under way at once.

N. J., Harrison—National Oil Products Co., Essex Street, plans installation of electric power equipment in new five-story addition to oil processing and refining plant. Entire project will cost over $150,000. Proposed to begin work soon.

N. J., Perth Amboy—Barber Asphalt Corporation, Insurance Co. of North America Building, Philadelphia, Pa., plans installation of electric power equipment in proposed new refining plant at Barber Station, Perth Amboy. It will consist of several large units. Cost reported close of $1,000,000.

N. Y., New York—National Gypsum Co., 190 Delaware Avenue, Buffalo, N. Y., plans installation of power equipment in new addition to plaster mill at East 148th Street and East River, N. Y. Work will begin soon. Entire project will cost over $350,000.

N. C., Durham—Borden Brick & Tile Co., Goldsboro, N. C., plans installation of power equipment in new branch manufacturing plant at Durham, where tract of about 50 acres of land has been secured near city limits. A boiler house will be built. Entire project is reported to cost about $75,000.

Ohio, Cincinnati—Stille & Dohlmeier Co., 1200 Wade Street, plans installation of electric power equipment in new five-story addition to furniture-manufacturing plant, 45 by 90 ft. Entire project is estimated to cost over $75,000. Work will begin soon. E. C. and G. T. Landberg, 116 Garfield Place, Cincinnati, are architects.

Pa., Ford City—Pittsburgh Plate Glass Co., Grant Building, Pittsburgh, Pa., plans installation of power equipment in connection with expansion and modernization in plate glass mill at Ford City, to be carried out over a period of months. Entire project is estimated to cost close to $1,500,000.

S. C., Orangeburg — Orangeburg-Aiken Hydro-Electric Commission, Orangeburg, has plans under way for new hydroelectric generating plant on Edisto River, with power dam about 50 ft. high and 16,500 ft. long, and initial station installation to develop a capacity of about 12,000-hp. A steam-electric power plant will be built at Graniteville, S. C., for auxiliary service. Project will include about 100 mi. of transmission lines. Cost reported over $1,000,000. Application has been made for permission. D. T. Duncan Engineering Co., Ninety-six, S. C., is consulting engineer.

Texas, Houston—Axelson Mfg. Co., 6160 South Boyle Street, Los Angeles, Calif., manufacturer of oil well-pumping machinery, parts, etc., plans installation of electric power equipment in new branch plant at Houston, comprising several one-story units. Entire project will cost over $150,000.

Texas, Houston—Vernor's Ginger Ale, Inc. of Texas, 4906 Harrisburg Avenue, plans installation of power equipment, conveying and other mechanical-handling equipment in new addition to plant for bottling division. Entire project will cost over $100,000. Work is scheduled to begin around close of this year.

Texas, Marshall—Bass-Ellis Lumber Co., plans installation of power equipment in connection with rebuilding of portion of lumber and planing mill, recently destroyed by fire. A new boiler house is being considered. Fire loss totaled about $50,000.

Texas, Pasadena—Champion Paper & Fibre Co., Houston Division, plans installation of electric power equipment in new addition to local sulphate pulp and paper mill, to be used for production of coated and other paper stocks. It will comprise several large units. Entire project will cost about $3,000,000. H. K. Ferguson Co., Hanna Building. Cleveland, Ohio, is engineer. Main offices of company are at Hamilton, Ohio. Reuben B. Robertson is executive vice-president.

Utah, Mount Emmons—Moon Lake Electric Association, Inc., Mount Emmons, plans steam-electric generating plant in connection with rural electric system, for power supply. Fund of about $285,000 is being arranged through Federal aid for plant and line construction. E. S. Conklin is superintendent, in charge.